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FIRST ALL-INDIA SEMINAR ON CITRICULTURE

NOVEMBER, 10-13, 1972

VTI HALL, AGRICULTURE COLLEGE,
NAGPUR

TECHNICAL PAPERS

UNDER THE JOINT AUSPICES OF
AGRICULTURE DEPARTMENT, MAHARASTRA STATE,
PUNJAB RAO KRISHI VIDYAPEETH, AKOLA AND
GOVERNMENT OF INDIA, MINISTRY OF AGRICULTURE
(DEPARTMENT OF AGRICULTURE) NEW DELHI

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TECHNICAL PAPERS

Compiled by :
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Director (Horticulture)
Govt. of India, Ministry of Agriculture, New Delhi.

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FIRST ALL INDIA SEMINAR ON CITRICULTURE
NAGPUR

(10-13 November, 1972)

AGENDA

Inauguration Ceremony.
(Nov.10, 1972)
(6.30 pm to 7.30 pm)

Venue: VTI Hall, Agricultural College, Nagpur.

Welcome Address	:: Shri H.S. Brar, Chairman, Horticulture Dev. Council, Government of India.
Inaugural Address	:: Shri V.P. Naik, Chief Minister, Maharashtra State.
Vote of Thanks	:: Shri N. Gopalakrishna, Vice-Chancellor, Punjabrao Krishi Vidyapeeth, Akola.
Reception (7.30 pm)	:: Maharajah Bagh, Agriculture College, Nagpur.
Ist Session (8.00 pm to 9.00 pm) venue-	:: VTI Hall, Agriculture College, Nagpur.

1. REVIEW OF CITRUS INDUSTRY IN INDIA

1(a) Review of Citrus industry in the States of Punjab, Haryana, Rajasthan & Western Uttar Pradesh - by - J.C. Bakshi, Joint Director (Research), Punjab Agricultural University, Ludhiana.

1(b) Review of Citrus industry in Jammu & Kashmir -

1(d) Scope of Citrus cultivation in valley areas of UP hills - by - Dr. S.S. Teaotia, Director, Fruit Utilization, UP, Ranikhet.

1(e) Citrusculture in Orissa - by Dr. R.C. Das, M.Sc.Ag.Ph.D. Department of Horticulture, Orissa University of Agri.& Technology, Bhubneswar-3.

1(ei) Citrus Industry in Eastern India - Bihar, Orissa and West Bengal States, by Dr. K.C. Bhan, Horticulturist, Govt. of West Bengal.

1(f) Review of Citrus-industry in North East India by A.R. Thapar, Adviser (Hort.) Govt. of Meghalaya, Shillong.

1(h) Citrus industry in Andhra Pradesh - A Review - by G. Siddalinga Reddy, Virus Pathologist, S.V. Agricultural College, Tirupati.

1(h) Latest Trends in Citriculture in Andhra Pradesh, by G.S. Swamy, N. Subba Rao, B. Ramayya, T. Dayanand, Regional Fruit Research Station, Anantharajupet (A.P.)

1(i) Review of Citrus Industry in Mysore State by Dr. M.H. Mari Gowda, Director of Horticulture, Govt. of Mysore and Dr. K.C. Srivastave, Dy.Director of Horticulture, Govt. of Mysore.

1(j) The progress and decline of 'citrus' in Tamil Nadu by J.S. Sundararaj, State Horticulturist, Tamil Nadu.

Nov.11, 1972
(9.00 am to 10.30 am)

Venue: VTI Hall
Agriculture College
Nagpur

2. CURRENT SITUATION REGARDING VARIETIES AND ROOTSTOCKS

Current Situation Regarding Citrus Varieties and Rootstocks by K.M. Aiyappa, K.C. Srivastava and K.M. Nanaiah, Citrus Die-back Scheme, Gonicoppal: Coorg.

.../-

Nov.11, 1972
(9.00 am
to
10.30 am)

Venue: Lecture Hall,
Agriculture College,
Nagpur.

3. RECENT ADVANCES IN CITRUS NUTRITION

3. Recent Advances in Citrus Nutrition by P.N. Takkar, N.S. Randhawa, J.S. Kanwar and J.R. Bhambota.

3(i) Studies on the root system of lemon (citrus limon(L) Burm.) var. GANDHARAJ. I. GROWTH and distribution of roots, their anatomy and nitrogen content, by S.P. Ghosh & P.K. Chattopadhyay, Department of Horticulture, University of Kalyani, West Bengal.

Nov.11, 1972
(10.45 am to
12.15 am)

Venue: VTI Hall
Agriculture College
Nagpur.

4. MODERN ORCHARD MANAGEMENT PRACTICES & CROP REGULATION IN RELATION TO FLOWERING, FRUIT SET AND FRUIT DROP.

4(i) Orchard management practices and crop regulation in relation to flowering, fruit set and fruit drop by P.K. Gupta, Punjabrao Krishi Vidyapeeth, Akola.

4(ii) Some suggestions towards mandarin orange growing (with reference to die-back problem) by K.C. Srivastave & K.A. Nanaiah, Citrus Die-back Scheme, Gonicoppal, Coorg, Mysore State.

4(iii) Intensive Area Programme for Oranges.

4(iv) Control of Kans (Sachharum Spontaneum Linn) with Bromacil Herbicide in young mandarin orange - some - preliminary observations - by Dr. A.V. Patil, Horticulturist, Regional Fruit Research Station, Katol (Nagpur).

.../-

4(v) 2,4-D Sprays improve the crop production in sweet orange by G.S. Swamy, B. Ramayya, T. Dayanand, M. Subbarayudu, Regional Fruit Research Station, Anantharajupet(AP).

4(vi) Problems & Prospects of Mandarin (*citrus reticulata* Blanco) in Mysore State - by K.R. Bhandary, R.K. Hedge & K.P.V. Shetty, University of Agri.Sciences, Hebbel-Bangalore.

Nov. 11, 1972:
(10.45 am to 12.15 am)

Venue: Lecture Hall
Agriculture College
Nagpur

5. HORMONES AS AN AID TO CITRUS PRODUCTION

5(i) Role of the Tristeza Virus in Citrus Die-back complex by S.P. Capoor, Senior Virus Pathologist IARI Plant Virus Research Station, Poona-5.

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Nov. 11, 1972
(12.15 pm to 2.15 pm)

LUNCH

Nov. 11, 1972
(2.15 pm to 3.45 pm)

Venue: VTI Hall
Agriculture College
Nagpur.

10. PRE AND POST HARVEST TREATMENT AND STORAGE AND UTILISATION AND BYPRODUCTS INDUSTRY.

...../-

Nov. 11, 1972
(2.15 pm to
3.45 pm)

Venue: Lecture Hall
Agriculture College
Nagpur.

8. BREEDING OF CITRUS ROOTSTOCKS AND VARIETIES TOLERANT TO DISEASES.

8. Breeding of Citrus Rootstocks & Varieties Tolerant to Diseases etc. by Ranjit Singh, R.N. Singh & S.K. Saxena, Division of Horticulture & Fruit Technology, IARI, New Delhi.

3.45 pm to
4.00 pm

TEA BREAK

4.00 pm to
5.30 pm

Venue: Lecture Hall
Agriculture College
Nagpur

11. ECONOMICS OF CITRUS PRODUCTION, INTERNAL MARKETING AND EXPERT TRADE.

4.00 pm to
5.30 pm

Venue: VTI Hall
Agriculture College
Nagpur

12. CITRUS PESTS

12. The pests of Citrus by Dr. B.L. Bhamburkar.

Nov. 12, 1972
(9.00 am to
1.00 pm)

Venue: VTI Hall
Agriculture College
Nagpur

6. ADVANCES ON CITRUS DIE-BACK COMPLEXES AND SCREENING OF GERM PLASM AGAINST VIRUS AND FUNGAL DISEASES.

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6(ii) Greening Disease of Citrus and its role in the die-back complex - by S.P. Raychaudhuri, T.K. Nariani & S.M. Viswanath, Division of Mycology & Plant Pathology, IARI, New Delhi.

6(iii) Role of Fungi in Citrus die-back complex by G.R. Singh and I.J. Kapoor, Division of Mycology & Plant Pathology, IARI, New Delhi.

6(iv) Role of vectors in citrus viruses with particular reference to citrus psylla in the greening 'virus', by O.S. Bindra, Prof.& Head, Deptt. of Zoology-Entomology, Punjab Agri.University, Ludhiana.

6(vi) Nematodes and Citrus die-back by A.R. Seshadri, Division of Nematology, IARI, New Delhi.

6(vi) A resume of work done in the decline of santra (citrus reticulata blanco) and Mosambi (citrus sinesia osbeck)oranges in Maharashtra, by N.A. Phadnis, A.S. Majumdar, A.G. Nevase.

6(vii) Nutritional Aspects in Citrus by K.C. Srivastave and D.P. Muthappa, Citrus Die-back Scheme, Gonicoppal, Coorg, Mysore State.

6(viii) Citrus die-back in Mysore State by D.G. Rao, and K.M. Aiyappa, Instt. of Horticultural Research, Bangalore.

9(i) Budwood from Nucellar Lines - A promising source in the citrus budwood certification programme by G.S. Reddy & V.D. Murti (S.V. Agricultural College, Tirupati).

9(ii) Budwood Certification for Sweet Orange: Its role in the future of citrus industry by R. Jayarajan, Plant Pathologist (Virus), Punjab Agricultural University, Ludhiana.

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<u>November 12, 1972</u>
(9.00 am to
1.00 pm)

Venue: VTI Hall
Agri.College
Nagpur.

9(iii) A plea for the establishment of integrated citrus advisory cells by B. Narasimham, Assoiate Prof.in Horticulture, S.V. Agri. College, Tirupati, A.P. Agri.University.

9(iv) Necessity of maintaining proper citrus nursery taking into consideration the problem of citrus decline by K.C. Srivastave & K.A. Nanaiah, Citrus Die-back Scheme, Gonicoppal, Coorg, Mysore State.

<u>November 12, 1972:</u>
(6.00 pm to
7.00 pm)

Venue: VTI Hall
Agri.College
Nagpur

<u>PLENARY SESSION</u>

<u>November 13, 1972</u> ::::::Excursion Trip to Katol and Warud Orange growing areas.

Item No. 1 (a)

A REVIEW OF CITRUS INDUSTRY IN THE STATES OF PUNJAB, HARYANA, RAJASTHAN & WESTERN UTTAR PRADESH.

by

J.C. BAKSHI

Punjab Agricultural University, Ludhiana.

.-.-.-.

The citrus industry in the States of Punjab, Haryana, Rajasthan and Western Uttar Pradesh is fast heading towards extinction. Imagination, skill, organisation and action would need to be pooled to save it from imminent ruination.

The past one decade has seen a lot of concern about the problem of citrus tree decline in this region and elsewhere in India. There have been determined efforts to ascertain causal and associated factors. The role of fungal diseases, viruses, insects, nutrients, rootstocks, cultural practices etc. has been investigated. Sufficient new information has come to light, but thinking as to remedial measures is yet confused. The coming decade needs to see a clarity of approach backed by well planned bold action in order to save the situation.

So much has been said and published, in the recent years in India about the problem of citrus tree decline that I hesitate to be repetitious. In brief, the Greening Virus, other viruses, insects, deficiencies of micronutrients, unsuitable rootstocks, injudicious intercropping, fungal diseases, improper water management, etc. have been implicated roughly in the descending order or importance. The problems facing citrus cultivation are multifarious including those of socio-economic nature which have not attracted due attention so far. Success in solving these problems would depend on the correct rating of their importance, fixation of right priorities and soundness of approach. The seminar, it is hoped, will devote itself to these tasks.

Problems of Low Yields

While yield is the most important factor in ...

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commercial citrus cultivation yet most of the investigations fail to throw sufficient light on it. For example, the studies on evaluation and correction of micronutrient deficiencies in citrus deal primarily with elemental status in leaves, before and after the application of micronutrient sprays, without the corresponding changes in yield. Such studies leave open the question whether the improvement in elemental status of leaves brings about reciprocal improvement in yield or not. Likewise, most of the reports on fruit drop, fruit set, etc. present treatment effects expressed in percentages as improvement or deterioration over the control without giving any clear idea about the magnitude or range of fruit yields. This limitation is common and widespread.

I have made an effort to screen out, from important Indian journals, those investigations where yields are reported. The screening is by no means comprehensive but its random nature should give a fair idea of the trends to draw valid conclusions.

In a study by Nautiyal (1955) the number of fruits borne, between the age of 18 to 20 years, on trees of several important varieties of sweet orange, mandarin, pummelo and grape-fruit in Uttar Pradesh were 100.5, 261.1, 74.1 and 75.7 respectively as an average for three years. The fruit drop ranged from 3.78 to 25.02 per cent, with the highest in pummelo and the lowest in sweet orange, so that the ultimate crop harvest was still lower. A report by Bajwa et al. (1957) indicated that the 8 years average yield in a sweet orange plantation under a manurial trial at Attari (from the age of 7 to 14 years) ranged from 100.6 to 233.1 fruits per tree per year under various treatments. The trees receiving no manure averaged 100.6, with farm-yard manure 137.1, farmyard manure plus ammonium sulphate 209.6 and with ammonium sulphate alone 233.1. The N was applied at the rate of about 55 gm per year age of tree.

Singh (1961) reported the influence of rootstocks on the yield of sweet orange variety Mussambi from Saharanpur. The rootstocks employed were Jambheri, Florida Rough, Seville Orange, Sweet Lime, Italian 76, Lime Sylhet and Kharna Khatta. The experiment was planted in 1952. Five years yields from 1957 - 61 ranged between 5.0 to 120.7 fruits per tree, taking into consideration all the rootstock and scion combinations. From yield and other points of view the sweet lime was considered as the most promising rootstock in the experiment. The 5 years average yield on sweet lime was 54.3 fruits per year per tree. The average on this rootstock in the ninth year (1961) after planting was 106.5

fruits. The maximum ever in any year and in any combination was 120.7 fruits per tree. In a similar study with Hill mandarin as scion and the same set of rootstocks (Singh 1962), the yield per tree between 5 to 9 years age of trees ranged from 11.3 to 133.4 in any combination in any year. Maximum fruit yield was observed on Florida Rough rootstock followed by Italian 76 with respective five years average of 84.2 and 68.5 per tree per year. In yet another similar study with Rangtara as scion and the same set of rootstocks the yields between 5 to 9 years age of trees ranged from 6.5 to 23?.3. The mean yield on the best rootstock (Florida Rough) was 108.1, with a five year range between 17.9 to 194.1 fruits per tree in any one year (Singh 1962).

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In a fertilizer cum rootstock trial, Singh (1961) reported the three years average yield (6 to 8 years age) of Musambi budded on Kharna Khatta and Florida rough to be 27.0 and 23.3 pounds per tree (composite for 3 levels of nitrogen). +The yield of Srinagar mandarin in the same experiment was 64.8 and 60.5 pounds per tree on Kharna Khatta and Florida Rough rootstocks respectively.

Bakhshi et al. (1963), while studying the effect of time of picking of valencias on subsequent cropping and fruit quality, reported three years yields of trees which were 14 years old at the start of the investigation. The average yield under various treatments worked out to 296 fruits per tree per year.

The studies of Dhillon and Singh (1965) on mature mandarin trees indicated a yield range of 166 to 217 fruits per tree under various treatments of growth regulators coupled with nitrogen. Singh (1963) reported a mean yield of 95.3 and 75.8 fruits per tree per year in case of Vanille variety budded on Kharna Khatta and Trifoliata orange rootstocks respectively. The maximum yield in any year in these scion/rootstock combinations between the age of 5 to 9 years was 151.8 and 139.2 respectively. This was obtained when the trees were 8 years old.

In a varietal trial on sweet orange planted at Abohar in September 1961 the mean yields between 1966-67 and 1970-71 were 16?.?, 106.0, 103.7, 144.0, 153.0 and 98.9 for Jaffa, Blood Red, Pineapple, Hamlin, Musambi and Valencia Late budded on rough lemon rootstocks. The percentage granulation ranged from 4.0 to 83.3. The minimum granulation was in

Blood Red and the maximum in Hamlin (Anonymous 1965 to 1970).

In an inter-cropping trial where trees of Blood Red variety budded on rough lemon were planted in September 1963; the three years average yields from 5 to 7 years age of trees were 76.7, 61.6, 94.9, 67.2, 81.5, 67.6, 78.4 for control (non inter-crop) and for cotton, gram, guara, berseem, chillies and peas as inter-crops respectively.

Manchanda (1970) conducted two fertilizer experiments on Blood Red variety budded on rough lemon. The trees were planted in 1961. In the first experiment was laid out on Split Plot design. A 1/8 pound of nitrogen for each year age of tree either as calcium ammonium nitrate (CAN), CAN + farmyard manure (50:50 N) or CAN plus senji as green manure was applied to main plots. On these basal treatments the sprays of Zn, Cu, Mn and Fe, either alone or in various combinations, were superimposed as foliar sprays in the subplots. The concentration of Zn was 0.5% and of other micronutrients 0.4%. The results are shown in Table 1 below:

Table 1

Effect of various treatments on yield, granulation and leaf zinc content

Treatments	Average No. of fruits per tree	Granulation %	Zn Content ppm
MAIN PLOTS			
CAN	126	63	15.8(When no
CAN+ F. Y. M.	129	65	6.5(Zn
CAN+ G. M.	132	60	12.8(applied (to main (plots.
SUB PLOTS			
Control	117	76	11.7
Zn	124	79	40.3
Cu	137	51	12.1
Mn	131	65	15.6
Fe	124	73	15.0
Zn+ Cu	144	42	38.4
Zn+ Mn	110	75	38.3
Zn+ Fe	145	61	43.5
	N. S. 5% C. D.	21.0	C. D. 7.0

In the second experiment zinc at 5, 10 and 15 ppm as soil application and one, two or three sprays of 0.5% zinc were given as main treatments. Fe, Mn and the combination of the two were superimposed as foliar sprays as the subplots. Elements were supplied in the sulphate forms. The results are given in Table 2.

Table 2

Effect of treatments on yield, granulation and leaf zinc content

Treatments	Average No. of fruits per tree	Granulation %	Zn (ppm)
MAIN			
Control	163	70	10.30
Zn 5 ppm	138	62	16.58
Zn 10 ppm	155	57	21.17
Zn 15 ppm	130	71	25.25
One Spray	113	39	24.67
Two Sprays	138	49	33.08
Three Sprays	145	57	35.67
	N. S.	N. S.	C. D. 5.96
SUB TREATMENTS			
Fe Spray	144	53	21.18
Mn Spray	158	58	22.39
Fe+Mn Spray	119	62	27.89
	N. S.	N. S.	N. S.

In another experiment (Anonymous 1960) 3 kg of CAN and one kg each of P_2O_5 and K_2O were applied as a basal dressing to 11 year old Blood Red trees at Jogiana near Ludhiana. Treatments of micronutrients were superimposed as foliar sprays at 0.4% concentration. The results are shown in Table 3.

Table 3

Effect of various treatments on chlorosis, elemental content and fruit yield.

Treatments	Average contents in leaves ppm			Fruit yield (Fruits/tree)
	Zn	Fe	Mn	
1. Control	11.8	175	21.1	125.0
2. NPK	10.3	169	21.8	131.7
3. NPK+ Zn	37.8	180	22.4	154.7
4. NPK+ Fe	15.1	380	23.6	140.7
5. NPK+ Cu	15.3	170	18.3	80.5
6. NPK+ Mn	16.4	167	61.1	113.0
7. NPK+ Zn+ Fe	15.0	288	20.9	96.7
8. NPK+ Zn+ Cu	21.9	166	25.4	88.7
9. NPK+ Zn+ Mn	27.2	210	27.0	188.0
10. NPK+ Zn+ Mn+ Cu+ Fe	20.2	303	34.7	98.2
C. D. 5%	6.7	23	8.17	18.2

The results reviewed above make it clear that irrespective of the nature of experiments and the place(s) where the trials were conducted, the yields in northern India have been pathetically low. It needs to be noted that the experiements have been reported from a wide variety of situations with different soil and climatic conditions. The yields are uniformly low. Obviously, therefore, the soil or climatic factors are not the basal cause for the poor performance of citrus in northern India. Likewise, in the experiments reported above, there are rootstock, fertilizer, varietal and inter-cropping trials. None has shown a respectable yield trend. This makes permissible the conclusion that all the existing varieties perform poorly with regard to yield irrespective of the soil conditions, rootstocks, cultural practices and the type of nutrition supplied. Could this be taken as a pointer to the fact that the basic defect lies primarily in the scion material used in propagation.

Examples for Comparison

The average yield of citrus in California over about 100 thousand acres in late fifties was about 600 fruits per tree (Bakhshi 1961). Several well maintained orchards yielded over 1000 fruits per tree per year. The situation in Florida seems to be still happier.

Many people contend that yields in California, Arizona, Florida, etc. are higher due to excellently suitable soils. Likewise, many horticulturists believe that yields in north-western India are poor because soils are saline and calcareous; and micronutrient deficiencies are wide spread. The Sharples and Hilgeman's (1969) paper from Arizona and several other similar studies from arid irrigated regions of California and Arizona provide an answere. In this study the influence of differential nitrogen fertilization on trunk growth, fruit size, quality and foliage composition of Valencia orange trees in Central Arizona was studied. The trees were originally of Marsh grape-gruit budded on sour orange rootstock and planted at 6.7 x 6.7 m apart in 1932. In 1950 Valencia was top worked. The differential treatments were started in 1958 i.e. 8 years after top working and 26 years after original planting. The soil characteristics are given in Table 4 and the yields in Table 5.

Table 4

Chemical characterisation of soil in plots receiving 0.45 kg of N/tree annually in 1966

Depth cm	pH of sat.paste	EC X 10^3 sat. extr. mmohs/cm (25^0C)	CaCO 3 %	Total* P mg/K dry soil	Total* K mg/K dry soil	Exchange K+ % of CEC
0.30	7.9	1.25	2.5	480	3900	4.3
30.60	8.1	1.20	4.3	470	4700	2.7
60.90	8.0	1.66	16.0	480	3100	2.1
90.120	8.1	1.56	14.6	450	2900	1.7

* Perchloric acid soluble

Table 5

Yield of Valencia orange trees in relation to amount and source of N fertilizer used.

N applied kg/tree	Mean Annual Yield fruit/tree '52-'57[2]	Mean Annual Yield fruit/tree '59-'66[3]	Mean Increase in Trunk Cross-Section, cm² '61-'66[3]	Leaf composition, % dry basis '61-'66 mean[3] N	P	K
0.00	383	662a	20.6a	2.00a	.110	1.13a
0.23US	374	728ab	21.6ab	2.21bc	.105	.90bc
0.45AN	394	809bc	23.9b	2.19b	.106	.92b
0.91AN	381	820bc	22.8ab	2.26bcd	.106	.87bc
1.82AN	379	858c	22.1ab	2.29cd	.107	.84bc
3.63AN	370	870c	22.4ab	2.33d	.107	.80c
0.91AS	389	848bc	23.4ab	2.23bcd	.105	.87bc
0.91CN	403	793bc	22.9ab	2.21bc	.105	.88bc
	ns	**	*	**	ns	**

1. AN - Ammonium nitrate, AS-ammonium sulfate, CN-calcium nit[rate], US- Urea foliage spray.

2. '52-57 yields from projected plots under uniform culture prior to experiment.

3. Means followed by common letters are not significantly different at the .05 probability value.

*F ratio exceeds 0.05 probability value.

**F ratio exceeds .01 probability value

ns - No significant differences between means.

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From the data given above, it is clear that in a saline and calcareous soil the yield of sweet orange, as a 7 year average, when the trees ranged in age from 9 to 16 years after top working and 27 to 34 years after planting, varied between 662 to 870 fruits per tree per year from the poorest to the best treatments. The need for better 'know-how' and skill to improve citrus industry in northern India is, therefore, obvious.

Plant Propagation in India

Anyone familiar with the past and present of the plant propagation and sale business in India would not need much time to be convinced that the defective and diseased plant material could well be the bane of citrus cultivation. Practically no attention has been paid to this important aspect. Under similar conditions, the fate of citrus industry in any part of the world could not have been much different.

The varieties in use are those evolved or imported decades and even centuries ago. They have been propagated and repropagated vegetatively for generations without any attempt either to clean or to invigorate them. There have been negligible attempts to evolve or import new varieties. Plants have been propagated at the same sites for years without any soil fumigation or disinfection. There are no regular sources of rootstock seeds nor any attempt for their establishment has been made. No efforts are made to disinfect either the seeds or the budwood before their use. The bud certification and quarantine are yet at the conceptual stages. The poorest plant material has been getting dispersed the most due to cheaper rates. There have neither been any research nor any extension education programmes on various aspects of nursery production. No worthwhile organisation exists either at the Central or at State levels to bring about the needed improvements in this field. Under the circumstances, it would be unrealistic to expect better performance from citrus orchards, when the basic plant material with which they have to be established is receiving scant attention.

The Price Factor

While the prices of non-perishable consumables have considerably increased over the past two decades, the prices of perishables like fruits and vegetables have either stayed static or have fallen down; often sharply. The cost of production has increased. Lack of storage and processing facilities, absence of price support,

and lack of appreciation of such problems about perishable commodities have put them to very serious disadvantage. The situation has become depressing as the yields and income from crops have increased considerably due to introduction of high yielding varieties and better agronomi[illegible] practices, while both yield and income in citrus has been going [illegible] of corresponding advances in citrus, [illegible] even for another one decade, would squeeze citrus and several other orchards out of existence.

Land Reforms

It will be difficult to revive the fruit industry from its present state of sharp decline if the land laws are not favourably amended. The reduction of ceilings on land holdings, imposition of wealth tax, frequent changes in agrarian laws, withdrawal of incentives to orchards, as contemplated by some State, would hasten the process of fruit tree removal which has already started at a fairly concerning rate.

This seminar will, therefore, have to take into consideration technical, organisational, legal and political aspects if the fruit industry in general and citrus industry in particular needs to be saved from the unwelcome fate towards which it is fast heading.

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4. Bakshi, J.C., Gurdarshan Singh & K. Kripal Singh. 1967. Effect of time of picking on fruit, quality and subsequent cropping of Valencia Late variety of sweet orange (*C. sinensis*). Ind.J.Hort. 24(1&2): 63-70

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7. Manchanda, H.R. 1967. Effect of different micronutrient sprays on chlorosis, granulation, fruit fall, yield and quality of sweet orange (variety Blood Red). J. Res. PAU. 4:508-15.

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ABSTRACT

The present status of citrus industry in the States of Punjab, Haryana, Rajasthan and Western Uttar Pradesh is reviewed. The fruit yields throughout the region are very low irrespective of varieties, rootstocks, manurial treatments, cultural practices, etc. Poor plant material, defective methods of plant propagation, lack of bud certification and quarantine, general lack of control over plant propagation and distribution are considered causal for the poor performance of citrus orchards in the region. Lack of price support, inadequate development of storage and processing units, frequently changing and unfavourable land laws and lack of adequate incentives have aggravated the problem. The fruit industry in general and the citrus industry in particular is fast heading towards extinction in these regions. A well conceived action plan is needed to save it.

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Item No. 1(b)

ALL INDIA SEMINAR ON CITRICULTURE
NAGPUR - 1972

REVIEW OF CITRUS INDUSTRY IN JAMMU & KASHMIR STATE

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INTRODUCTION

Nature has been kind enough in giving the State of Jammu and Kashmir such a soil and climate wherein diverse type of fruits are being grown. The State is located in the North-Western corner of the country within Northern hemisphere in between 32° latitude, 73° longitude and 81° East of Greenwich. State can safely be divided into four Agro climatic zones, lower belts adjoining plains of Punjab and Haryana forms the Subtropical zone with altitude varying from 800' to 2000', the zone falling between an altitude of 4000' to 8000' comprises the temperate zone and above 9000' is the arid zone. The area falling between an altitude of 2000' to 4000' is treated as intermediate zone.

Due to the favourable climatic conditions in the sub-tropical zone located in Jammu Division of the State the citrus in numerous forms is being grown. The cultivation of citrus has no cited history in the state and the introduction of cultivated varieties has recent origin but citrus in wild forms is of common occurance.

SOIL AND CLIMATE

Citrus, as has been mentioned, is being grown in the subtropical zone between an altitude of 800' to 2500' and there are places in the intermediate zone where citrus and Apple are successfully grown in one and the same orchard. The temperature in the subtropical zone varies from 5 degrees to 45 degrees centigrade with an average rainfall of 1150 mm to 1500 mm having maximum precipitation during July and August. In this zone summers are hot and dry with some what frosty conditions in winter.

Soils under citrus zone vary from sandy loam to clay loam, the soils are low to medium in Nitrogen, phosphorous and potash. The Southern plains under citrus are partly irrigated and partly rainfed while as Northern area is mostly rainfed.

VARIETIES AND ROOT STOCK

As has been mentioned elsewhere citrus in wild forms is of common occurance and types like Jhamberi, Khati, Rough lemon, Karnah Katha, Galgal etc. are fairly available. The fruit of

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these is locally consumed in making pickles, beverages and vegetable locally known as "Ambel" and also for juice which is used for dressing slads etc. The varieties of cultivated types which have been introduced in the State are as follows:-

S.No.	Type	Variety
1.	Sweet Orange	Washington navel, Valencialate, Blood Red Musambi.
2.	Mandarin	Naagpuri, Loose skin, Batwal, Kinnow.
3.	Grape fruit	Pink Marsh.
4.	Lime and Lemon	Kagzi lime, Mitha Chikna, Baramasi, Hill Lemon.

Multiplication of Plant material in general is being carried out by the Department of Horticulture at the Departmental nurseries. Root stocks used are rough lemon and Kathi which are commonly available. It has been observed that the "citrus decline" is mostly common in Kathi root stock but diseases like Phytophthora decline and Gummosis are not common on such root stocks in the State.

CULTURAL PRACTICES AND ORCHARD MANAGEMENT

In general the plantation of citrus is sporadic but a few years back some orchards have been established in the vicinity of Jammu and other towns. Sporadic plantation is not looked after properly on strict scientific lines except for occasional fertilization, weeding, hoeing and removal of diseased parts of the plants. Most of the time vegetables like cauliflowers, potatoes, cabbage etc. are raised as intercrops and no attention is paid to the fertilization and manuring to compensate depletion by such intercropping. The only scientific effort the orchardist does is at the time of digging and filling up of the pits and plantation when proper filling of the pit with soil manure mixture and later staking of the plants to protect against strong winds is being practised. As regards irrigation, in rainfed areas the orchards are left at the mercy of nature and under irrigated conditions weekly irrigation in summer and monthly irrigation in winter is being given to the orchards.

No proper manuring or fertilization is being done by the orchardists, however, the Department of Horticulture through its extension agency persuades the orchardists to have their soils tested and the fertilizers recommended, applied for the better returns.

PLANT PROTECTION

Numerous pests and diseases as are found in the adjoining plains of Punjab and Haryana can also be located on citrus in the subtropical zone of Jammu & Kashmir State. Citrus Dieback has gained its foot hold during last decade and is causing a profound threat to the citrus industry and its future extension. The decline is observed mostly on plantation above 2 to 3 years of age and has seriously affected the extension of area under Citrus culture. Experiments are in hand on raising of Nuceller seedlings, raising virus free stocks and by substituting the present plantation by Hybrids like Kinnow. Strict quarrantine measures are also to be adopted for stopping the infiltration of plant material from plains of Punjab, Delhi and U.P.

The Department provides plant protection machinery free of rent to the orchardists for spraying their orchards against pests and diseases with technical assistance. Adequate quantities of pesticides are stocked by the Department at easily accessable places in the potential areas for combating the enemies of the fruit trees. Other pests/diseases such as Aphids, leaf minors, pyrilla, caterpillars, white fly, citrus canker are also prevalent and the Departmental extension agency persuades the farmers to adopt timely plant protection measures to ensure the control of such diseases and pests.

AREA AND YIELD

The estimates of the area and average yield of Oranges, Limes and lemons and other citrus fruits is as follows:-

S,No.	Kind of Fruit	Area under cultivation in Hectares	Total yield in metric tonnes
1.	Oranges	220.4	1367.21
2.	Limes and Lemons	45.5	87.66
3.	Other citrus fruits	128.3	892.5

On an average about 500 to 900 fruits are harvested from a grown up tree for santra and Malta and in case of Lime 700 to 1000 fruits are yielded by a mature tree.

MARKETING AND UTILIZATION

The fruit is used for table purposes and is mostly consumed locally as there is no surplus for export to other areas. Beverages like squashes etc. and other preserved products are made from the fruit on home scale.

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SUMMARY

Citrus cultivation in Jammu & Kashmir State is mostly confined to the subtropical zone falling in Jammu Division of the State. As in other places, the Citrus industry in the State has been stagnant over the last decade due to the serious inroads made by Citrus diseases, particularly of virus origin. The plantation is mostly scattered and no proper scientific cultivation is being practised. The varieties commonly grown falls in Mandarin or Sweet Orange group. Root stocks employed are rough lemon and local Katki. Yields are poor and production is not enough even for local consumption or feeding to a large scale processing plant. Efforts are under way to overcome Dieback menace and place this industry on sound footing.

ALL INDIA SEMINAR ON CITRICULTURE NAGPUR - 1972 Item No. 3(d)

SCOPE OF CITRUS CULTIVATION IN VALLEY AREAS OF U.P. HILLS

By

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Some of the citrus varieties are successfully grown in valley areas of hills as well as upto elevations of 2300 metres. The important citrus growing areas are mostly in particular tracts, the important being near Bageshwar which extends upto Kap-kote-Laharkhet. It further extends upto Sama-Tejan Girgaon. The others citrus belt is located in the valley areas of Ram Ganga, Gagas and Gomoti rivers around Chaukhutia, Dwarahat, Dunagiri and Dudholi. The most important orange growing areas are located around Pauri and Srinagar in Pauri-Garhwal and Chaukot in Almora district and Gauchar, Chamoli and Guptakashi in Chamoli district.

Out of the citrus varieties grown in the above areas, hill lemon is most hardy and grows in every type of soil because of its wide adaptability.

A local variety of Santara is grown in most of these areas and the quality of these oranges grown in Remari, Bhaiskot, Askot and Balwakot is excellant. Specially a particular local variety grown in Srinagar area has been given this very name because of its superior quality. The important orange growing areas fall mostly in calcarious soil belts with lime stone. Apart from hill lemon and the local variety of mandarin, some indigenous varieties of lemons such as Matkekri and a variety resembling attoni are also grown in some pockets of valleys. It is, however, worth mentioning that the citrus orchards and isolated citrus plants in these areas are of seedling origin. These citrus plants are comparatively more hardy and do not appear to suffer so extensively by citrus decline. On the other hand, the budded plants procured from important nurseries situated in the plains do not thrive well in these localities.

From the brief account given above, it is evident that although systematic efforts were not made in the past to develop citrus plantation and citrus industry on a scientific line, the quality of the fruits of the varieties grown locally is far superior to that of the important citrus tracts situated in the plain. This is because of suitable soil and climatic conditions of the valley areas where the fruits start ripening early in the month of November and develop good colour.

The scope of improvement and extending citrus cultivation in these areas in unlimited if the work is started on the following lines and sciantific solution is also provided to the local problems.

(1) Detailed soil survey of the citrus growing area should be done and proper manurial recommendations should be made.

(2) Most of the plantations existing in the hill areas have been established by seedling plants and are comparatively healthier and fairly free from virus diseases. Therefore best use of nucellar embryony should be made. Best nucellar plants should be selected and planting material should be raised from seeds obtained from them.

(3) The root stocks suitable in the plains have been generally observed to be unsucceessful in the hills. It is, therefore, necessary to select the best root stocks for the varieties grown in hilly valley areas.

(4) The local citrus varieties are adopted to the soil and climatic conditions prevailing here. The improvement of these varieties should, therefore, be done by proper selection and wherever necessary hybridization for specific object should also be tried.

Item No. 1(e)

ALL INDIA SEMINAR ON CITRICULTURE
NAGPUR - 1972

CITRUS CULTURE IN ORISSA

By

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Bhubaneswar-3

INTRODUCTION

In Orissa State, as per report available, citrus fruits grown in the State seems to be 3281 acres producing 11,987 tons (1965-66) annually (3) which is likely to be under mandarin oranges. Another source shows that Orissa is having 12,000 acres under citrus (1959) producing about 60,000 tons of fruits annually and fruits are available from October to February.

However, the actual area under various citrus fruits (Mandarins, Sweet oranges, Limes, Lemons, Sower orange, Pomelo, Grape fruits etc.) grown in the State has not yet been assessed. It is a fact that the citrus growing areas of the State are scattered in the areas of Northern Agency tracts Mayurbhanja, Keunjhar, Sundargarh, Bamanda, Palhara, Bonai, Angul, Jharsuguda and in the Western ghat Parlakhemundi, Ramgiri Udyagiri, Surangi, Badekhamundi and Potangi, Niamgairi hills in Koraput district.

Environmental conditions prevailing in the Citrus growing areas:

In general the soils of Orissa can be broadly classified into seven groups - Red soil, Laterite, Alluvial, Saline, Black, Forest hill soils and mixed red block soils (1) In the district of Koraput we find mostly Red loam and forest and hill soils. Black soils, red loams and Forest soils are common in Kalahandi district while in Bolangir district red soil and Black soils are common with alluvial soils along the river basins. In the district of Sambalpur mixed red and black soils are common with alluvial soil near Mahanadi river beds. Sundargarh district fall under red soil group with some forest soils. Mayurbhanja and Keunjhar have mainly red and laterite soils present side by side. In the district of Phulbani a greater part of the district is covered with forest soils, red soils and few patches of black soils. Dhenkanal district has red soils and Ganjam

has saline soil along the coastal belt but major area is covered with red & black soils and laterite and forest soils are also found towards the western side. In the district of Balasore aluvial laterite, and saline soils are common while Puri and Cuttack districts the major areas are covered with alluvial, laterite and saline soils.

With regards to temperature and rain fall the State enjoys average day temperatures of 91°F maximum and 50°F minimum with a distribution of 101°F maximum and 73°F during April & May, 70°F maximum and 60°F minimum during December-January. However during summer in the Northern range the temperature goes up to 110°F. In the Eastern Ghat region maximum temperature goes up to 104°F and minimum during winter 36°F. In the sea belt it remains at 87 to 89°F with very mild winter during the winter months.

The rain fall in the four different zones (Northern, Central, Eastern Ghat, and sea belt) varies 47.98 to 67.29", 48.92 to 70.22, 45.65 to 60.82 and 48.10 to 66.82" respectively.

Varieties grown:

In the State more or less all kinds of citrus can be grown. Mandarins, Sweet oranges, Sower orange, Limes, Lemons, Grape fruits are grown in the areas specified elsewhere in this report. Even in the hilly areas mandarin oranges are grown quite successfully. Among mandarins Nagapur santra in the Northern Orissa and Patakamala, Surangi kamala in the Southern Orissa are doing good. Even in the Niamagairi hills where aboreinals are living the mandarins are growing well which are quite likely from Polyembronyic seedlings. The lime is also doing good in South Orissa.

Research:

The first research programme started on citrus in this State as early as 1939-40 (5) at citrus fruit research station Sambalpur on 50:50 basis of State Government and I.C.A.R.

Root Stock Trial:

Experiment on root stock trial for Nagapur Santra having Jamberi (c.limonia), kichili (C.Madres-patna), Jatikhati (C.limonia), Karna khatta (C.Karna) and Jambehri seeds collected from Bombay, Madras and local, Kandhia local (C.aurantium). Sweet lime were

tried both at Sambalpur and Angul and now the work is extended to R. Udyagiri. The results of the Angul research station indicated that Nagapur santra on Jambhari local Karna khatta had 100% survival during 1958-59 of a plantation made during 1950, while Jambhari Madra, Sweet lime had 97.50 and 93.75 percent respectively. Jambhari Bombay had 75% and kandhia local (C. arantium) and karuna local (C. arantium) had only 6.405%.

Manurial trial, irrigation trial and fertilizer trials did not result any convincing results due to improper experimentation.

Trial on Nagapur Santra, Mosambi, Washington naval, Valencia and Jaffa oranges have indicated that these can be grown with success specially Washington navel and Nagapur santra. Observation on Mosambi at Horticultural Research Station at Bhubaneswar shows that this can be grown successfully and the fruits are available when mandarins are not available in the market. However Nagapur santra were not growing well.

In the hills of Niemagiri, district Koraput, quite a good number of mandarins are grown by the aboriginals which are grown without much care and the plants in general are observed to be from nucellus seedlings. But in the other hills of this district like Pottangi, Nissar areas grafted plants of N. Santra and other oranges are having troubles of plant motelling and dieback. This die-back is noticed in most of the citrus growing areas of the State. Further fruit drop of citrus has become serious in the entire State. Studies on these problems are needed very quickly. Even though clean cultivation is the general orchard practice, the proper nutritional and water management are yet to be established. Macro and Micro nutrition, hormonal control and use of mucellus seedlings of citrus varieties rather than grafts with unsuitable and uncompetable stock and scion are some of the problems to be tackled. Virus free plants are needed for which careful steps are to be taken, lest citrus cultivation may face grave consequence.

ABSTRACT

Orissa is growing citrus specially Mandarins, sweet oranges, grape fruits, limes in different parts of the State. The problem of suitable planting material, proper nutritional, water and plant protection management is lacking as a result the citrus growing areas are now facing danger like the attack of die-back disease, fruit drop and early death of trees. Steps are required to be taken to find out ways and means for proper citri culter in the various citrus growing zones so that commercial production of various citrus species could be successfully grown in the State.

ITEM NO.1 (e i)

CITRUS INDUSTRY IN EASTERN INDIA - BIHAR ORISSA AND WEST BENGAL STATES

BY K. C. BHAN

In India citrus fruits rank next to mango and banana in acreage, occupying an area of about 1,05,396 hectares, which amounts to about 11.6 per cent of the total area under fruits in the country. In the eastern region, particularly in Assam, citrus fruits occupy pre-eminently an important place in the fruit industry, having an acreage of about 12,160 hectares in Assam, 14,000 hectares in Bihar, 1,849 hectares in Orissa and 2,157 hectares in the West Bengal, States. Mandarin orange is the most important citrus species from commercial point of view grown in this region, though sweet orange, limes and lemons, and pomelo are also grown extensively in homesteads.

Soil and climate

In Bihar both mandarin and sweet orange are mainly grown in Palamau and Ranchi Districts of Chhotanagpur plateau. This tract with gravelly, red lateritic soils, generally well drained, and a moderate rainfall of about 1,335 mm in Palamau and 1,482 mm in Ranchi appears to be well suited for orange cultivation. Limes, lemons and pomelo are grown scattered all over the State. In the northern districts soil is sandy loam and in the rest of the State it is mostly clay loam.

In the Orissa State both mandarin and sweet orange are grown in the hill regions of Koraput, Ganjam and Phulbani and in some parts of Dhenkanal and Sambalpur districts. Orange cultivation is mostly confined to altitudes ranging between 600 to 900 metres above mean sea level, though orchards may also be found on higher elevations upto 1500 metres. Precipitation in this region is rather heavy, about 1,600 to 1,700 mm annually. The soil types found in the orange belt are mainly red, black and lateritic, mostly acidic in reaction. The limes and lemons are, however, grown scattered in rich alluvial soils all over the State.

In West Bengal mandarin is the most important citrus fruit in the hilly region of the Darjeeling district, occupying an area of about 800 hectares. Orange plantations are usually found at altitudes varying from 500 to 1,300 metres above mean sea level. Mandarin is, likewise, an important citrus fruit in the Sikkim State. Orange cultivation is mostly concentrated in Kalimpong and Kurseong Sub-divisions of Darjeeling district, which have an annual rainfal ranging from 2,000 to 3,500 mm. The soils vary from loamy to clay loamy and are mostly acidic in nature. Sweet orange is not grown on any appreciable scale in West Bengal, though trials have shown that it can be grown successfully in the lateritic tract of Bankura, Purulia, Birbhum and Midnapur districts. Limes, lemons and pomelo are the other citrus fruits commonly grown all over the State.

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Considering the suitability of climate for citrus fruits, it can be safely stated that mandarin is better suit for high rainfall areas, whereas sweet orange does better in drier parts of the region. It is reported that in Orissa St the performance of Nagpur mandarin has been disappointing, a it is claimed that Sylhet and Assam mandarines are better suited to the orange belt as the latter can withstand heavy rainfall better, which, however, needs confirmation.

Varieties

No systematic efforts seem to have been made to stu a large number of citrus species found growing almost wild in the eastern region, particularly in the sub-montance and low hills of Orissa and West Bengal States. Among the cultivate species, mandarin (Citrus reticulata) ranks first in area an production. Nagpur santra is mostly grown in Orissa and Bih whereas in Darjeeling it is the Sikkim type of mandarin predominantly cultivated. Botandically speaking, Nagpur san Sikkim and Sylhet oranges appear to be same, though there ar morphological differences among them apparently due to agro-climatic factors.

Sweet orange (Citrus sinensis) comes next to mandar in importance. Several varieties of sweet orange including Mosami, Batavia, Malta, Jaffa, Valencia and Washington Navel have been tried, but the reports indicate that Mosambi is mos suitable for this region. Apart from Mosambi, Malta variet has also given promising results in the lateritic tract of West Bengal. Washington Navel does fairly well in the hills of Darjeeling district. Valencia, a late variety which does not mature earlier than February-March, is subject to excessi granulation and dehydration of the fruit due to water stress.

Two types of acid limes (Citrus aurantifolia) are mostly grown in the eastern region, of which Kagzi which has more or less round, higly acidic fruit with characteristic flavour is more popular. The other type, called Pati, has oblong fruit, less acidic than Kagzi. Several varieties of lemon (Citrus limon) are grwon in this region, of which Assam lemon or China Kagzi (seeded and seedless types) is the most popular, whereas among the lesser important types are Gandhraj(a highly fragrant type), Nepali, Malta, Halian, etc. Experience has shown that lemons grow better than limes in hills and are less succeptible to citrus canker. Apart from limes and lemons, sour orange, locally called Gora lebu, rou lemon (Jamir) and a large number of hybrids with these and perhaps other species as parents are found growing almost wild in this region.

Pomelo is another popular citrus fruit grown in the eastern region. It is a hardy fruit and shows good adaptabil to tropical climate. Many varieties of pomelo are grown, some of which are excellent in quality. Krishnanagar No. 3, a clonal selections made at the Horticultural Research Station, Krishnanagar, is an excellent type. Stalkart is another variety deserving special mention on account of juiciness. Sweet lime (Citrus limettioides) is also grown on a small sc in homesteads, but commercially it is not an important fruit in this region.

A study was undertaken at the Horticultural Research Station, Krishnanagar, to determine the quality of different types of limes, lemons and other members of the acid group grown under similar conditions. The data obtained, presented in a table below, shows that fruits of Pati lime and Lisbon lemon have the maximum juice content, 48-49 per cent, compared with 29 per cent of Seedless lemon. The citric acid content of Pati lime is 6.31 per cent compared with 5.90 per cent of Seedless lemon and 5.35 per cent of Lisbon. Sour orange and Khatta Punjab have the lowest citric acid content. The ascorbic acid content of Pati is only 20.80 per cent against 38.02 per cent of Lisbon. Seedless lemon is unexpectedly low in ascorbic acid content. Rough lemon and Jamberi are also poor in ascorbic acid content.

Table. Fruit quality of some Citrus species

ty	Average weight in gm.	Juice content per cent	Total soluble solids per cent	Citric acid per cent	Ascorbic acid mg/100 gm of juice
lime	51.12	48.50	8.42	6.31	20.80
less lemon	156.20	29.09	7.85	5.90	19.80
a lemon	108.77	43.47	8.29	5.74	38.60
n lemon	109.17	48.70	8.45	5.35	38.02
a lemon	144.84	45.09	7.85	4.90	35.17
araj lemon	303.88	25.50	7.79	5.30	18.22
n	628.21	38.90	7.35	4.30	23.90
lemon	235.72	30.80	7.35	3.56	19.45
a Khatta	423.16	20.60	9.36	5.04	22.23
eri	306.72	23.10	8.83	5.05	14.60
a Punjab	195.11	29.09	7.79	2.48	23.04
orange	233.40	33.93	8.29	2.07	27.60

Propagation and rootstock

Mandarin orange is generally propagated from seed. The plantations raised from seedlings come remarkabley true to type due to high degree of polyembryony. It can also be propagated by air-layering but this method is seldom used.

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Sweet orange is usually propagated by budding, though sometimes air-layering is also practised. Other citrus fruits such as limes, lemons and pomelo are usually propagated by air-layering or cuttings. However, experience has shown that pomelo budded on pomelo rootstock grows much faster and produces healthier plants than when propagated by air-layering.

The position with regard to use of rootstocks for mandarin and sweet orange has not yet crystalised. In Orissa trials on different rootstocks including Rangpur lime, citrus trifoliata, sweet lime, Karnakhatta and Jamberi are still in progress. The observations made so far suggest that Karnakhatta followed by Jamberi, is more suitable than the rest for sweet orange. In West Bengal no systematic research has been conducted on rootstocks; however, it is observed that Jamberi is better suited on account of its high tolerance to root rot diseases. Rootstock trials conducted in Maharashtra State have shown that Rangpur lime is the most suitable rootstock for both mandarin and sweet orange. It will be worthwhile trying Rangpur lime in the eastern States.

Planting and aftercare

It is customary to prepare terraces on slopy lands in hilly areas for the purpose of planting seedlings or grafts. Pits of the size 2 to 3 feet each way are dug and the excavated soil is mixed with manure and then returjed to the pits. There does not appear to be any scientific data to suggest as to what should be the depth of the pit, and the type and the quantity of fertilisers to be applied at the time of planting. Recommendations are usually made empirically and sometimes based on personal experience.

It is well known that the life of a plantation depends greatly on the orchard management practices adopted. Water is essential for plant growth but excess of it is equally harmful; it has been observed that water logging for even 7-10 days may cause premature death of the trees. Irrigation is seldom practised in mandarin orchards in West Bengal, unless they are intercropped with millets, vegetables or maize. However, in the lateritic tracts where soil is deficient in moisture irrigation at an interval of 7-10 days is necessary. It is, indeed, unfortunate that little or no research work has been done in the country to determine the water requirements of citrus and other fruits.

Intercropping in young orchards is generally practised in the hilly areas and crops such as millets, maize and vegetables are grown. However, intercropping of citrus orchards in the plains is seldom practised though it is advocated to balance economy of the growers during the pre-bearing period, which can, of course, prove harmful unless judicious management practices are followed. Exceessive ploughing or deep digging

of the soil usually causes injury to the roots.

Manuring

No systematic fertiliser trials appear to have been conducted to determine the nutritional requirements of citrus in the eastern States. Various recommendations made on hypothetical considerations, or some time based on experience, have been made. In Orissa, annual application of a NPK mixture supplying 1.5 lb of N, 1.0 lb of P_2O_5 and 1.2 lb of K_2O per tree to 5-year old orange trees is advocated. In Darjeeling district growers generally apply 80-100 kg of farm yard manure or leaf compost and about 2 kg of castor oil cake to a fully grown orange tree. The use of inorganic fertilisers is still limited to progressive growers only. The applicationo of dolomite in acidic soils is becoming increasingly popular in the hills.

Not much is either known of the micronutrient requirements of citrus in this region. There are reports of magnesium and zinc deficiencies in the hills and the lateritic tracts of West Bengal.

Fruit drop

In West Bengal prematur e fruit drop of sweet orange and mandarin during August-September is an acute problem of great magnitude. Experiments conducted at the Horticultural Research Station, Krishnanagar, showed that the premature fruit drop could be reduced to 50 per cent by spraying 10 ppm 24D with a suitable sticker two to three times at an interval of 3-4 weeks during the period from June to August.

Harvesting and yield

In West Bengal mandarin is harvested between November and January. In the case of sweet orange Mosambi is harvested in September-October, while Malta is ready in November-December. The average yield of a fully grown, well maintained mandarin orchard usually averages 3,000 fruits per tree. The yield of sweet orange is low, generally 200-300 fruits for 8-10 year old tree, which is due to high rate of premature fruit drop during the period from July to September. Kagzi lime has been recorded to yield 1,500 to 2,000 fruits per tree, but the yield of lemon seldom exceeds 1,000 fruits per adult tree.

Marketing of citrus fruits

Marketing of citrus fruits in the eastern region still remains outdated. According to a marketing survey conducted in West Bengal, it was found that about 20% of mandarin got damaged and completely lost in transit from the orchards to consuming centres. Damage to the fruit was also observed during picking in the orchards. The marketing losses could be substantially reduced if methods of harvesting, packaging and transport could be improved.

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Citrus fruit processing industry

The citrus processing industry is still confronted with the age-old problems of supply of sugar and containers at reasonable prices. Besides, the production of citrus fruits in India, particularly in the eastern region, has not recorded any increase; the production has perhaps decrea eddduring last few decades. The cost of fruit at the consuming centres is quite high and uneconomical for the processing industry, though the grower hardly gets more than 50% of the ultimate sale value, With a view to put the citrus processing industry on sound footing, which has a definite future and can be potentially a good source of foreign exchange, the production of citrus fruit should be stepped up expeditiously on a planned scale.

Pests and diseases

Numerous insect pests are known to cause considerabl damage to the citrus plants by boring the stem, sucking the sap and devitalising the plant, eating leaves and other parts, or as virus vectors. The pests reported to cause losses of economic consequence are stem borers, leaf minor, aphids, mealy bugs, mites, fruits flies, fruit sucking moth, white fly, lemon butterfly, etc. Many mandarin plantations in Darjeeling district have met premature death due to attack of stem borers. The incidence of fruit fly attack during the last decade or so in Darjeeling district, which causes premature fruit drop sometimes to the extent of 50 per cent of the total crop, has become so serious that growers are find ing mandarin growing as uneconomical . Leaf minors cause greater damage to sweet orange and pomelo than mandarin and limes and lemons. Mealy bugs if not controlled in time can cause severe defoliation and devitalisation of the affected tree. Fortunately, the control measures of the different insect pests are fairly well known and timely action can prevent grevious loss to the grower. What is required, indeed, is that the grower should be made conscious of the necessity to practice plant protection measures in his orchard as a matter of routine.

Diseases are a much greater and complicated problem for the citrus grower than insect pests. There are numerous fungal, bacterial and virus diseases attacking citrus plants. Among the fungal diseases foot rot gummosis, caused by Phytophtchora sp., is the most important single factor responsible for citrus decline and premature death of sweet orange as well as of mandarin orchards in the eastern region. Anthracnose (C. gloeosporioidas) and fruit rot (Alternaria citri) are also known to cause considerable damage to the citrus plant. Citrus canker (Xanthomonas citri) is the only bacterial disease of commercial importance known to-day.

There have been several reports of the prevalence of citrus viruses in India, among which tristesa, psorosis and, lately, greening virus have assumed considerable importance. However, our knowledge of the actual damage caused by the different viruses in India is still limited. In Darjeeling

..Cont.: P.7.

district greening virus is fairly well spread in mandarin orchards, and it is likely that other viruses are also present in this region. A systematic survey of the entire region only can throw light in the distributuon and importance of the different citrus viruses.

The selection of suitable rootstocks resistant to soil borne diseases and showing tolerance to viruses is perhaps the only practical approach to the problem. It is encouraging to note that a breeding programme to develop rootstocks combining disease resistance with other desirable characters has already been taken in hand at the Indian Agricultural Research Insitute, New Delhi.

ACKNOWLEDGEMENT :

I wish to express my heartfelt thanks to Shri K.C. Shukla, Horticultural Development Officer, Bihar, and Shri R.C. Gardatia, Joint Director of Agriculture(Horticulture), Orissa, for kindly furnishing information on citriculture for their respective States.

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Item No. 1(f)

REVIEW OF CITRUS INDUSTRY IN NORTH EAST INDIA
BY A.R. THAPAR, ADVISER(HORTICULTURE)
GOVERNMENT OF MEGHALAYA, SHILLONG.

THE region comprises the States of Assam, Meghalaya and Nagaland; Union territories of Manipur and Tripura and the North East Frontier Agency comprising a total geographical area of 2,35,580 sq.kms, excluding Nagaland, Fig 1, I must confess that I do not claim to have first hand knowledge of the conditions obtaining in the entire region. The account given in this review is based on observations made during my short stay and sporadic travels in Meghalaya and parts of Assam and whatever I could gather from the published records, personal contacts and discussions with workers in Horticulture, in the area. This region enjoys a unique distinction not only in India but in the world, as being very rich in numerous forms of citrus and being the original home of several citrus species both edible and non-edible. Bhattacharya and Dutta (1956), after a protracted survey lasting over a decade, recognised 17 (seventeen) species including a new one and their 52 (fiftytwo) varieties and 7 (seven) natural hybrids met with in this region and described them in detail. This citrus species endemic to this region include the Indian Wild orange, citrus indica Tanaka and citrus assamensis, Dutta and Bhattacharya and the non-edible, C.ichangensis, swingle, the Khasi Papeda, C.latifoes (swingle) Tanaka, and c. macroptera. According to these workers, C.aurantium, c.magaloyycarpa, the sour pummelo and a variety of C.reticulata are also probably indigenous to this region.

<u>The present status of citrus industry:</u> In order to assess the present status of the industry in the region, a questionnaire was sent to the Directors of Agriculture, Assam, Nagaland, NEFA, Tripura and Manipur. They were good enough to respond to my request. No information however, was received from Nagaland and as such could not be included in this review. The information so gathered is presented below in table 1. It may be noted here that the statistics of area under horticultural crops and citrus fruits are more in the nature of estimates rather than exact figures based on actual surveys, in almost all cases.

IT will be seen from Table 1, that among the citrus fruits, the major area is occupied by mandarin followed by lemons and limes and that under sweet orange is negligible. It is significant to note that despite special efforts made at the citrus research station, Burnihat to introduce varieties of sweet orange, namely valencia Late, Washington Navel, Mosambi, Blood Red etc. and grapefruit into this region, very little headway could be made in this direction. Those varieties later on met with a serious decline at the station itself which engulfed the entire citrus plantation, not only at the station, but also in the vicinity. A belief is also held in certain quarters that plant introduction, propagation and dissemination activity at the station might have unconsciously led to the dissemination of the citrus decline in the region through the virus infected plant material

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Table 1

	Assam	Meghalaya	Nagaland	Manipur	Triputa	NEFA	Total
ra- al in ns.	99,528	22445	N.A.	22,070	10,537	81,000	2,35,580
tal- iva- area ec- s	21,91,775	1,57,018	"	1,04,166	2,50,000	22,100* 56,250+	27,81309
ea r hort s in ares.	3,07,171	59,219	"	17,920	22,330	3,300	4,09,940
ea r cit- fruits ectar-	Mandarin						
	3333	5900	-	2083	861	330	12507
	Lemons:						
	1250	1100	-	1622	478	neglible	4450
	Sweet orange						
	neglible		-	-	-	-	-
tal under us ts.	4583	7000	-	3705	1339	330	16,957.

Table II.

Area under citrus fruits reported in Assam region from time to time

Name of Distt/area	Area reported from time to time. Mitra & Khongwir 1928	Report on Marketing oranges 1944-45	Hayes 1951 Hect-area	Bhattacharjee. (1961-62) Hectares	Figures reported State D of Agri 1970-71
	Acres	Acres			
para	40	200	11776	10630	As given the last column of table
up	330	2200			
ang	160	300			
ong	-	42			
gar	40	270			
r	50	1200			
i Hills	107	450			
ya Frontier t	-	28			
Hills	47	500			
J Hills	10628	5200			
pur	30	N.A.			
Hills	NA	160			
l area ectares.	11,522 4800	10,700 4400	11776	10630	16957

:* Permanent
+ Shifting cultivation } In table I.

The above figures show that the total area under citrus fruits remained more or less the same over the period 1928 - 45, between 4-5 thousand hectares. However, when the districtwise figures are examined, a marked incr... in area is noticed in all the districts during the period except Khasi and Jaintia Hills, the main citrus growing area, where on the other hand, there was a steep fall. This may be due to the fact that the area for this district was grossly exaggerated in 1928, or it was very much under-estimated in 1944-45, the latter being more probable. According to the Report on the Marketing of Citrus Fruits in India, (1943), the area under citrus fruits in Assam was estimated at 14,025 acres equivalent to about 6000 hectares which seems more reasonable than given in the Report of Marketing of Oranges in Assam (1946). Mitra & Khongwir (1928) reported that the cultivation of mandarin was rapidly increasing in the hills and plains of both the Surma and Assam Valleys besides the Khasi Hills and was extending rapidly to the neighbouring hills of Garo, Jaintia, Gachar and Lushai. The figures reported in 1957, 1960-61 and 1970-71 are considered no more reliable than those reported earlier. They, however, show that plantings were going on during this period even though the trees were dying by the thousands due to die-back disease. It is only in the last few years, that many growers have realised the 'futility' of planting any more trees till the disease is controlled and the area is now considered either stationary or on the decrease in most cases. One can see a marked trend in the diversion of the citrus area to arecanut plantations in the Khasi and Jaintia hills and from the age of arecanut palms, it can be deduced that this trend must have set in the last decade.

PRODUCTION: In the report on marketing of oranges in Assam (1946), the total production is estimated at 2,436,000 mds equivalent to 87,000 tonnes considered to be the highest in the country at that time. Allowing for local consumption of 2 per cent and wastage of 10 per cent, the supply available for the market was estimated at 79,395 tonnes and taking the price at Rs.10/- per md, the value of the fruit available for marketing was estimated at Rs.21,436,800/-. It is estimated that during 1961-62, the production of loose skinned oranges in North East India was 95,670 tonnes, (Bhattacharya (1971). The present production is not known exactly. Assam has reported an average yield of 3.5 tonnes per acre for all citrus fruits. It is also reported that the production is gradually decreasing due to die-back. There is hardly any area that is not affected by this disease and the yield varies depending on the severity of the disease. Das (1971) reports a production of 52,000 tonnes of mandarins; 21,500 tonnes of limes and lemons and 4,000 tonnes of sweet orange totalling 78,000 tonnes in Assam. Manipur has also reported a yield of 3.5 tonnes per acre for mandarins and 3 tonnes per acre for lemons. According to the Director of Agriculture, Manipur, the production is probably stationary. In Tripura and NEFA no realistic estimates regarding production of citrus fruits

are available. However, the production of Assam lemon is reported to have increased considerably in Tripura during the last 5 to 6 years due to increase in area. The production of mandarin is reported to be decreasing due to the advancing of the bearing trees. The total production of citrus fruits in Meghalaya is estimated at 76,641 tonnes and there is a marked downward trend in production every year.

The present position regarding the statistics of area and production is anything but satisfactory and may even be misleading. It is to be hoped that the position may be some-what better as a result of the agricultural census currently underway in the country. A visit to citrus orchards in the region leaves onein no doubt that the trees are suffering from a serious decline and the industry is not only stagnating, but deteriorating rapidly. There is a visible reduction in the number of trees per unit area due to mortalities and the remaining trees are dwindling in health and production. Very little new plantings are being done except of lemons in certain areas. The citrus industry in the region seems to be heading for a crush if not rescued from the malady to which it has fallen a prey.

CLIMATE: The citrus fruits in this region are grown in three well defined topographical situations, namely, the Brahmaputra and Surma valley plains with elevation ranging from 61 to 152 meters, sub mountain regions between 152 to 610 meters and mid hills above 610 meters above sea level. The limes, lemons, the citrus and the pummelos predominate in the plains and are found to some extent in the sub-montane tracts. The Khasi mandarin (citrus reticulata) par excellence of commerce is mostly confined to the sub montane regions though it is also seen at higher elevations upto over 1525 meters. Some species of citrus like citrus inchangensis, and C.latipes grow wild at attitudes higher than 610 meters, Bhattcharya and Dutta (1956).

The climate of North Eastern region is characterised by moderate temperature and high humidity. Its most distinguishing feature is the copious pre-monsoon showers between March and May when conditions of drought prevail in the rest of upper India. The rainy season is a prolonged one upto the middle of October. Winter months are dry. Thus the citrus trees are subject to extreme wet conditions in the summer and very dry conditions in winter for about three months from November to February.

The most important mandarin growing section lies in the middle of the southern slopes of the Khasi and Jaintia Hills especially along hill streams. The annual precipitation in the areas is upto 5000 mm. The highest rainfall areas of the world namely Cherrapunjee and Mowsynram with annual precipitation as high as 15,000 mm lie close to this region. The average annual maximum temperature, average minimum temperature and humidity at the citrus Research Station Burnihat for a typical year are 8,169, and 86 respectively. The average maximum temperature seldom goes beyond 94°F, and the minimum below 40°F. In citrus growing areas in Assam, the maximum and minimum temperatures remain round about 90°F respectively

In Manipur, the rainfall varies from 1400 to 2500 mm., the maximum and minimum temperatures 100°F and 45°F respectively. The rainfall in citrus growing ranges of Shakhan and Jampci in Tripura varies from 2472 to 2528 mm. In NEFA rainfall varies a good deal from about 4000 mm to 5000 mm in the sub-tropical region.

SOIL: Broadly speaking the soils in the hilly areas are lateritic and red loams while those in the Brahmaputra and Surma valleys are alluvial. Due to heavy rains and consequent erosion, the soils on the slopes bordering on East Bengal tend to be sandy, gravelly and shale. The soils are mostly acidic in reaction except those along the main river banks, comparatively rich organic matter and Nitrogen but deficient in phosphoros. They respond well to the application of manures and fertilizers. The following table III gives the result of analysis of the soil and sub-soil of the citrus Experimental Station* Burnihat conducted during May 1961.

The soils in citrus growing regions in Assam are reported to be sandy loan to clay loam with p^H ranging from 4.5 to 6.00 In Manipur, the p^H of such soils is reported to vary from 5.5 to 6.00 while in Tripura, Assam lemons are being grown on well drained lateritic soils having low-sub-soil water table and low p^H - 4.5 to 5.5. The mandarins, however, are grown in hilly and forest soils of lateritic group having lime stone deposits both in Tripura and Meghalaya.

The facilities for analysing soil samples either do not exist at all or are very meagre. The manurial and fertilizer applications in most cases are therefore unrelated to the nutrient status of the soil and are generally arbitrary.

VARIETIES:

1.MANDARIN: The varietal situation is rather a simple one as the main citrus variety grown in Assam, Meghalaya and NEFA is the famous Khasi mandarin locally known by the name of Soh Niamtra in Khasi Hills. Plant, leaf, flower and fruit characters have been described by Bhattarcharya and Dutta (1956). Some salient characters are given below:-

Tree medium to tall, 15 to 25 ft, erect, densely foliaged both thorny and thornless, fruiting season November to February, one crop in a year, prolific bearer upto 4500 fruits per tree recorded.

Leaf medium size, dark green, pertiolo rudimentary and wingless.

Fruit depressed globose to oblate, big, orange yellow to bright orange, neck low, sections often showing through the rind, adherence very slight or more, segments 8-13, usually 10, septa very thin, pulp vesicles uniformally orange coloured, very melting, flavour agreeable, juice abundant, sweet, sweetness and acidity well blended, seeds usually 10 to 15 per fruit, medium sized, polyembryonic.

It is grown extensively all over Assam as a commercial crop. Bhattarcharya and Dutta (1956) rated it so high that

See Para 'Soil' Table #III.

Ingredients	Top Soil	Sub Soil
Course sand	5.3 percent	19.5 per cent
Fine sand	25.2	21.5
Silt	36.0	24.0
Clay	28.0	39.0
Moisture	3.6	8.6
Nitrogen	0.215	0.71
Phosphorus	0.014	0.006
Potash	0.054	-
p^H value	5.2	5.2

according to them it is destined to retain its present status throughout the whole future of the citrus industry of the region. It has a wide range of adaptability to diverse soils and climatic conditions. The area under this variety was estimated as 20,000 acres in 1948.

In Manipur, the variety of mandarin grown is locally known as 'Komala'. It is not known if it is a strain of Khasi mandarin or is a definite variety by itself. Its yield per acre is reported to be the same as that of Khasi mandarin in Assam.

The mandarin grown in Tripura is reported to be a distinct type by itself. However, the brief description of fruit given does not differ in any way from that of Khasi mandarin.

2. LEMONS: The main variety grown in Assam, Meghalaya and Tripura is the Assam lemon. The variety grown in Manipur is called Champra. It is not known whether it is a district variety by itself or is some form of Assam lemon.

The present strain of Assam lemon is said to have originated as a chance seedling in the Citrus Station, Burnihat from the progenies of the variety collected under the name of China-kaghi from village Hashara, Sibsagar Dist. The fruit of this chance seedling was found to be strikingly superior to that of its progenitor in respect of yield and quality. It was propagated vegetatively as a clonal horticultural variety and named as Assam lemon, Bhattacharya and Dutta (1956).

In Assam and elswwhere in the region, lemons are grown in almost every home for catering to domestic needs and it is only rarely that large scale plantations on commercial scale are seen. Of all the varieties grown, Assam lemon is by far the best combining quality with yield. The variety has already attained a considerable popularity with growers and the area under it in 1944-45, was estimated to be 5000 acres. It bears all the year round with the peak period of production during June to September. It is used in the green matured stage for garnishing and culinary purposes. The variety is fairly resistant to scab, canker and gummosis to which most of the other varieties are susceptible.

The salient tree, leaf and fruit characters of this variety are as under: Tree or shrub 6-8 feet high, straggling, thorny, prolific bearer, leaf medium sized, upper ridge green, pale green beneath, petiole wingless, twigs very slighly purple tinged; fruit oblong to rather longish, gradually narrowing towards the base, colour lemon-yellow, skin smooth, glossy, rind thickness 5-6 mm. segments 9-12, pulp vesicles crystal white, juice abundant, very sour, flavour good, seeds none or several, usually seedless.

3. Karimganj Lime. A small tree or a shrub, bushy, height 6-10, heavy yielder, peak season August to October, sprinkling of crop almost all the year round; fruit light greenish yellow, skin-smooth, thin, juice plenty, sour, flavour excellent, seeds 9-14 per fruit.

It is heavy fruiter and more than a thousand fruits per tree in the peak season is not unusal. It is less susceptible to scab, canker, and gummosis, than Abhaypuri Lime which is elliptical or egg shaped.

Besides the mandarin, the lemon and lime described above there are several less important varieties and strains of mandarin, lemon, sweet orange, sour orange, rough lemon etc. sold in the local markets. All of them are described in the monograph on Citrus Fruits of Assam, by Bhattacharya and Dutta (1956). As already referred to earlier, the new introductions,- of sweet orange, mandarin, and grapefruit though seemingly successful to begin with, failed to take a foothold in this region and have since been relegated to the background.

Propagation and Rootstocks: Almost all mandarin trees are of seedling origin throughout the region. Raising of plants from seed is the rule and 2-3 years old seedlings are planted. As regards lemons, here again, the trees are on their own roots, having been propagated from layers.

Experiments on different methods and time of budding were carried out at the Citrus Station, Burnihat and it is reported that the inverted 'T' with wood registered the highest percentage of success, the best period of budding being from October to January. Two sets of rootstock trials were also laid out at this Station, in early forties. In one of the randomised and replicated trial five indigenous rootstocks namely (a) Rabab (Tenga (Shaddock), (b) Soh Myndong (Rough lemon), (c) Pani Jamir (Lemon), (d) Karun Jamir (Seville orange) and (e) Satkara (C. Macroptera Mont) were worked with Khasi mandarin and another observational trial was laid out with 4 trees each of 14 rootstocks namely 1. Bira Jora (Citron) 2. Jora Tenga (citron), 3. Soh-Myndong (rough lemon, Jambhiri) 4. Tulia Tenga (lemon), 5. Kata Jamir (lemon), 6. Muri Tenga (lemon), 7. Soh Sarkar (C. Karka), 8. Ada Jamir (citrus assamensis), 9. Soh-khylla (hybrid-tangelo), 10. Karun Jamir (Seville orange), 11. Rabab Tenga (Shaddock 12. Satkara (C. Macroptera) 13. Soh-Jay (Citrus sp) and 14 Soh-Kumprick (C. Sp) with five scions namely Khasi mandarin, Washington Navel orange, valencia late orange, Blood Red orange and Grapefruit

Certain indications were noted in earlier years in the root-stock scion behaviour according to which Soh-myrdong (rough lemon) and Soh Sarkar (C.Karma) appeared suitable. Tulia Tenga and Kata Jamir (lemons) also appeared to be promising. Bira Jora and Jora Tenga (citron) were unsuitable. Sarkara (C.Macroptera) induced dwarfness.

The trees were propagated on promising rootstocks and made available for general planting. It was soon obserbed that the trees began to suffer from a serious decline after a few years and the initial expectations of their superior performance were soon belied. In fact, the trees began to manifest the same symptoms in the Research Station itself and the industry again relapsed into the old system of seedling trees but it was soon discovered that even the seedlin trees began to suffer the same fate which had befallen the budded trees.

A rootstock trial in order to be conclusive must run a full course covering the entire life span of the trees. In these trials the trees began to suffer from serious decline quite early in life, and thus the results were vitiated to a large extent. Dr. Lilian Frager (1966) who visited this Station in 1966 observed the prevalence of greening virus on a large scale and while reviewing the results of rootstocks trials in the country, questioned the utility and even necessity of such large scale trials when the greening virus was affecting the scion varieties directly and suggested that the behaviour of trees in root-stock trials should be re-examined in the light of presence of greening as well as triteza.

There has been a tendency on the part of research workers to reject the stocks which lagged behind in vigour and yield per tree, although their performance otherwise was satisfactory in respect of general growth, vigour, quality of fruit etc. It seems necessary also to review the results or re-orient the future trials in order to select suitable rootstocks having a range of vigrour with a bias towards dwarfing and semi-dwarfing rootstocks as that would enable more efficient handling of the trees in respect of control of diseases, insect pests and vectors, pruning, picking of fruits etc. With the regulation of distance of planting, these trees may yield as well or even out-yield the bigger trees requiring larger spacing. In this respect some rootstocks like Satkara (C. Macroptera); Soh kumprick (citrus sp), calamondin type Narangi of Assam (C.Reticulata), Sindhuri-Nemu tenga (C.Jambhiri) bearing a close resumblense to Rangpur Lime deserve a special mention.

<u>ORCHARD MANAGEMENT</u>: 1. <u>Cultural practices</u>: An almost semi-wild system of cultivation is practised in citrus orchards in the region in general and the Khasi and Jaintia hills in particular, The orchards, are all mixed; a conglomoration of orange trees, tezpat, areca palms, jackfruit and forest trees of all sorts. No proper spacing or alignment of trees is followed

Compact and properly aligned plantations of citrus trees ar met with very rarely. A common belief seems to have gained ground with the growers that the orange trees do well under shade and the rather steep topography and profuse natural vegetation on the slopes also seems to have favoured this system of culture. Except the clearing of the shrubs and undergrowth once a year, no other cultural treatment is practised in most cases. The so-called orchards thus brave extreme conditions of neglect from the very beginning to the trees. In Tripura, some growers are reported to give 2 to 3 weedings to the trees in a year.

2. Irrigation: Citrus orchards are grown under rainfed conditions in this area. In summer months when the rainfall is excessive, conditions of temporary water logging are created in soils which are not naturally well drained. In winter, there is very little rain and trees, especially in young orchards face conditions of drought and consequent starvation which lead to yellowing and mottling of leaves and drying of twigs. The trees on soils underlaid with sub-soils containing a higher per centage of sand from which the water is lost by percolation suffer the most. It was at one time considered to be the main cause of the dieback of which hundreds of trees died year after year.

3. Manuring and fertilisation: Enquiries made on this aspect in the region reveal that but for the application of some quantity of farmyard manure in the initial years, no regular manurial and fertilizer schedule is followed and by and large the trees are left to fend for themselves. No wonder that the trees suffer from malnutrition which together with the excess of moisture at a certain times of the year and the lack of it at other time throws the trees out of gear. A fair amount of work on citrus nutrition was done by different workers in Assam, Bhattacharya and Dutta (1945), Chowdhury and Dutta (1950), Chowdhury(1954), Dutta (1959) and their findings were reviewed by Aiyappa and Srivastava (1967). Deficiencies of major element N, and minor elements like magnesium, boron, sinc, iron, copper manganese and molybdenum are indicated. On the other hand, Dr. Lilian Fraser in her report (1966), has remarked "there is no evidence either from foliar symptoms or analysis that deficiency of copper or manganese exists in commercial citrus areas. The symptoms attributed to zinc deficiency, or detailed study, do not agree with simple zinc deficiency symptoms, as known elsewhere. In no area has more than a slight and temporary improvement been obtained with even the heaviest and most frequent zinc applications." According to her, "any possibility of relationship to zinc deficiency has been completely eliminated by the extremely thorough work carried out at Coorg and Burnihat. The response of greening affected trees of various varieties on various rootstocks will almost certainly be different from that of virus-free trees, since greening appears to exert a profound influence on metabolism. Since all fertilizer trials are being carried out with trees affected with a virus which itself appears directly to affect tree physiology, accumulation and utilisation of nutrients, leaf analysis can therefore not be used as a basis of ascertaining

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nutritional deficiency and any conclusions based on those cannot be accepted as valid.

Be that as it may, the fact remains that the results of the fertilizer trials have not found application in the field. This may be attributed to the weakness of the Extension Agency or that the recommendations at best resulted in only marginal improvements or both. Also very few people really know the full range of visual symptomology of nutrient deficiencies.

4. Plant Protection Measures: The citrus trees are attached by a number of insect pests and diseases. They have been reported and described by Chowdhury and Nag(1947)/, and (1955)c and Reddy (1968), The insect pests found damaging the trees are Papilio demoleus - the lemon butterfly, Phyllocnistis, citrella stait - citrus leaf miner, Ophideres fullonica - fruit sucking moths, pacrorticha siziphi-leaf rolling larvae, chloridolum alemene. citrus stem and shoot borer, rhynchocoris humeralis - citrus greenbug, toxoptera aurantii- citrus aphids, diaphoria citri citrus psylla, monohammus versteeri- trunk borer and scale insects etc.

/Chowdhury, S, (1951), (1952), (1954), (1955) a, (1955)b,

The common fungal diseases are phytopthora prasitica, dastur gummosis, foot rot and collar rot, sphaceloma fawcetti citrus scab, bark rot or foamy disease, yellowing disease, dieback, collectrichum gloeo spuriodes withertip capnodium citri-sooty mould, alga spot and disporthe citri-melanose.

The main bacterial disease is xanthomonos, citri-dowson-citrus canker. Lately virus diseases like Tristeza and greening have been reported and are doing a serious damage especially the latter. The presence of nematodes is also indicated in certain areas.

Among the insect pest, citrus trunk borer is the most serious pest of Khasi orange. According to Dutta (1959), the trunk borer is the most important enemy of citrus in Assam and is responsible for about 20 per cent mortality in the mandarin plantations. It seems the citrus plantations had to reckon with this enemy from very early times as Mitra and Khongwir writing in 1928 draw a pointed attention to the depredations of the borers so such so that many plantations had to be abandoned owing to their attack and bearing trees of 12 to 15 years were seen to turn to almost fuel-wood. They mention that in some places mandarin orchards had flourished in the past but on account of serious attack of borers the old orchards had all disappeared.

Out of the large number of fungal diseases found attacking the trees perhaps the Phytopthora is the greatest killer. The bacterial disease citrus canker is prevalent throughout the region doing extensive damage mainly to limes and lemons.

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Plant protection measures in general have been undertaken only on a limited scale. They were not much effective and the plantations had to live with the natural enemies, the growers always filling up a large number of gaps in them due to casualties every year. This went on till the late forties or so when the unnoticed contamination with tristeza and greening viruses made the already bad situation much worse. Dr. Capoor and party from the Indian Agricultural Research Institute, New Delhi who paid a visit to this area in 1964 reported perhaps for the first time the large scale infestation of the citrus orchards in Assam and the present Meghalaya with Tristoza and concluded that the main cause of the dieback/symptoms were aggravated by the nutrient deficiencies in soil, improper aeration of roots, non manuring of orchards and the prevalence of pests and gummosis. However, Dr. Lilian Fraser who visited these areas two years later ascribed the decline more to greening virus than trizteza. She made a number of recommendations; 8 short term and 19 long term, on pages 38 to 42 of her report which implemented will go a long way in checking the decline and rehabilitating the industry./continues to languish and is now almost in the wilderness. It is felt that for implementing the recommendations made by Dr. Lilian Frager a pre-requisite is a multi-disciplinary research-cum-development station in each of the States/Territories in this region coupled with enactment of suitable legislation for the introduction of nursery certification, destruction of the infected trees and adoption of a strict plant protection schedule.

Marketing: Eastern India stands unique in its geographical isolation from the rest of the country with which it is connected through a narrow corridor in West Bengal. It has to depend for transport upon the meter gauge railway line that winds through West Bengal. The transport problem of the region is thus a class by itself and the high transport costs are a serious deterrant to the export trade.

Before the partition of the country, the main export of oranges was by country boats and steamers. The Chhatak market in the Sunamganj Sub Division of Sylhet was by far the most important centre where the oranges were collected from adjoining Khasi and Jaintia Hills. The other important markets are Karimganj, Gauhati and Shillong. The fruit was sent to Calcutta and other places in Bengal. It was purchased by pre-harvest contractors who arranged the marketing. With the partition of the country, the entire marketing system was thrown out of gear. The growers suffered as the traditional outlet for the fruit was no more available. The orchards being no more paying were further neglected and this perhaps coincided with the period when the virus diseases had also begun to affect the general health of the trees.

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At present only a small quantity of fruit finds its way from the border markets into East Bengal. The major portion comes by road to Shillong which itself is a big consuming centre. From Shillong the fruit goes down to Gauhati, another big consuming centre and the surplus moves further down to Calcutta by road and rail via the circuituous corridor referred to above.

Though no accurate statistics are available of the quantity of fruit consumed locally and that exported out of the region, yet the general observations go to show that the quantity exported is becoming less and less. It is packed and transported in bamboo baskets of variable sizes which in different centres contain anything from fifty to five hundred fruits. As the previous marketing survey was carried out before the partition of the country, it is high time to undertake a fresh survey to assess the present situation which besides providing information on the existing situation may suggest important improvements for the profitable outlet of the marketable surplus.

Utilisation: The main varieties of fruits grown in the region are suitable for processing. There is however, a need for locating and propagating seedless strains of Khasi Orange for canning purposes. Nagaland and parts of Assam grow sizeable quantity of seville orange which is used extensively in United Kingdom and Spain to make Marmalade Bhattacharjee,(1971).

There were only two fruit preservation units manufacturing a small quantity of fruit products in North East India during 1952, as against 572 units manufacturing 11,929 tonnes of fruit and vegetable products in the country. The number increased to 10 during 1956 and 19 during 1963. There are now 22 such factories in the area as against 1034 in the entire country. The breakup category-wise is as follows:-

State/Territory	Large-scale Factories manufacturing products worth one lakh of Rs. annually.	Small scale Factories mfg prod. worth Rs. 0.5 to 1 lakh annually.	Cottage scale mfg prods. upto Rs. 0.5 lakh annually.
Assam	2	1	10
Meghalaya	-	2	1
Manipur	-	1	1
Nagaland	-	-	1
Tripura	1	-	2
	3	4	15

It is seen from the above table, that by far the largest majority of the processing units are either Cottage Scale or Small Scale. It is estimated that during 1968, the industry in N.E. India produced 449 tonnes of fruit and vegetable products valued at Rs.15.68 lakhs as against 252 tonnes valued at Rs.5.05 lakhs during 1963 and 56 tonnes valued at Rs.1.23 lakhs during 1956, Bhattacharjee (1971). According to one

estimate, 120 tonnes of oranges were processed in 196?, in this region against the All India figure of 2486 tonnes. Thus, the processing industry is utilizing a very small fraction of the total production and there is a good scope for increase in the off-take of the fruit by this industry. This will not only help the horticulture industry but will also meet the demand for these products of the armed forces located in the region.

Summary and Recommendations: The review deals with the citrus industry in North East India comprising the States of Assam, Meghalaya and Nagaland; Union territories of Manipur and Tripura and the North East Frontier Agency covering a total geographical area of 2,35,580 sq.kms, excluding Nagaland. The region enjoys a worldwide distinction of being a repository of numerous forms of citrus some of which originated here. The citrus industry in the area assumed sizeable proportions early in the present century and it seemed to flourish and expand for some 3 to 4 decades after which it began to decline in the late forties or early fifties. Although the statistics of area and production still manifest an upward trend, yet actual observations in the field show that the industry is threatened with a serious 'decline' and is heading for a crash unless saved by suitable timely measures.

The major area is under Khasi mandarin, followed by lemons and limes the main variety being Assam lemonand that under sweet orange and grapefruit is negligible. The efforts at citrus Station Burnihat in introducting the budded varieties of sweet orange and grape fruit though seemingly successful for a short period proved abortive belong long and in the process, perhaps led to the inadvertant introduction and dissemination of virus diseases, namely tristeza and greening which spelt the death knell of the plantations not only at Burnihat and its vicinity, but through out the entire region.

The neglect of orchards in way of cultural practices, nutrition, plant protection etc. has been a regular feature of the industry from its very inception causing mortalities in the plantations and sapping the vitality of the remaining trees, yet it struggled along with a fair degree of success when the super-imposition of viruses referred to above, quickened the pace of decline. The ameliorative measures wherever undertaken proved no more than mere palliatives and soon the growers raised their hands in despair and the industry is now completely in the wilderness. A package of practices has been evolved in the light of experience gained locally and elsewhere mainly dealing with nutritional and plant protection aspects, but neither the growers are in a mood to adopt them in view of their past failures, nor the Extension workers are in a position to vouchsafe their effectiveness due to the advance stage of the decline of the trees, It is felt that an accurate appraisal of the citrus industry is the immediate need of the region which may throw light on the various aspects dealt

in the review including acreage, production, marketing, utilisation etc. as no such survey has been conducted after the partition of the country which gave it a severe jolt, depriving it of the traditional channels of transport and avenues of disposal of the produce. The industry also needs a new-direction which can best be given by locating a multi-disciplinary Research-cum-Development Station in each State/Territory supported by a powerful research wing attached to either the Agricultural University in the region or by establishing a separate Research Institute for citrus fruits in the Eastern Region and enacting suitable legislation for effective implementation of the programme.

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Item No. 1(h)

ALL INDIA SEMINAR ON CITRICULTURE
NAGPUR - 1972

CITRUS INDUSTRY IN ANDHRA PRADESH - A REVIEW

By

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Andhra Pradesh is one of the leading citrus growing States in India with an area of about 25,000 hectares - 15,000 hectares under sweet oranges (Sathgudi, Batavia, Mosambi) and 9,000 hectares under acidlimes. Mandarin oranges are grown to a limited extent in the Agency tract while vadlapudi oranges are a rare commodity today.

Prior to 1935, all citrus plantations comprised of seedlings only and they were in good bearing condition upto 50 years or more. During 1935-'45, about 1,500 hectares of Vadlapudi orange industry in Guntur and Krishna districts collapsed due to 'water injury' and perhaps due to tristeza virus as well. With the establishment of the Fruit Research Station at Kodur in 1935, improved methods of citrus growing were experimented and by 1945 Sathgudi budlings on Jamberi rootstock showed distinct advantage of early cropping, heavy bearing and quick returns to the grower. Consequently, by 1948 use of Sathgudi budlings became very popular all over South India. Such plantations exhibited enormous promise in the first 10-20 years. However, during the peak bearing age most of them started declining due to root-rot. All efforts made to save such plantations met with utter failure. Acidlime plantations also met with the same fate. As such, citrus growers in Andhra Pradesh were at cross roads regarding the choice between seedlings and budlings. At this critical juncture, naturally the citrus growers turned their attention to the experimental results at the Fruit Research Station, Kodur.

CITRUS ROOTSTOCK EXPERIMENTS AT KODUR:

Sathgudi: i) Sathgudi on sathgudi registered high yields, better fruit quality and high disease resistance. Billikichili was the next best rootstock. Kichili was good.

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ii) Gajanimma, acidlime, gabbuchinee and jamberi were precocious but susceptible to tristeza and other viruses and hence declined early. Gajanimma was the highest yielder. Yet it was not preferred as a rootstock due to poor quality of fruit and high susceptibility to diseases.

iii) Unworked seedling sathgudi trees were huge in size, very late to commence cropping and yielded about ¼th of the budlings on sathgudi stock.

Based on the above results, as early as 1960, the Fruit Research Station, Kodur recommended sathgudi on sathgudi to the commercial growers. All said and done, the commercial citrus nurserymen (with the exception of one nurseryman) showed little interest and enthusiasm in preparing sathgudi budlings on sathgudi rootstock because of poor vigour, less bud take and long time taken to prepare budlings on sathgudi stock. From nurseryman's business point of view jamberi is excellent in every respect and hence over 95% of sathgudi budlings supplied to growers even today are on jamberi only. In the absence of any legislation or some other voluntary organisation restricting the indiscriminate multiplication of citrus nursery plants, the present trend of faulty nursery practices continues.

Since 1960, the Fruit Research Station, Kodur and one commercial nurseryman at Kodur have supplied limited sathgudi budlings on sathgudi stock to different people. Limited observations show that such gardens are not better than those on jamberi. The probable reason is that since 1960, practically virus infected budwood is invariably propagated and hence the merits of sathgudi rootstock are nullified by the evil effects of the virus infections in the scion.

In view of wide prevalence of a multitude of viruses in our citrusplantations, some citrus growers ask - why not we switch back to use of sathgudi seedlings in all future plantations? Unfortunately, the experimental results at Kodur are strongly against seedling because of late bearing and low yields ultimately. Such a failture is possibly due to the fact that in early 1950s the entire Kodur - Rajampet citrus belt was planted with sathgudi budlings and the different viruses like tristeza, greening, psorosis, mosaic and so on could spread all over and adversely affect the prospects of citrus industry in Rajampet area. In other major citrus tracts like Pulivendala, Siruvel, Anantapur etc., few of those who went in for seedling sathgudi plantations burnt their fingers badly because such gardens did not commence cropping even after 10-13 years and the owners had

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to grub them out of uttar helplessness. Shallow soils may be partly responsible for the failure of seedlings in these areas. Further, poverty - ridden citrus growers in Rayalaseema could not afford to wait for 10-15 long years to get their first harvest from seedling plantations. They wanted quick returns even if the plants were to die out within 15 years. Budded plants alone answer their needs and expectations.

At the same time it is also true that in an area of about 1,000 hectares sweet orange seedling plantations in West Godavari are high yielding, long lived and quite remunerative. This particular tract is isolated and represents deep red loams well suited for seedling plantations. Since the tract was under seedling plantations for long, these gardens are so far faring well. But since sweet orange budlings from Kodur tract are interplanted during the last 10 years, it is surmised that the prospects of the seedling plantations may not be as good as the older ones in another decade. This is a guess based on circumstantial evidence.

Acidlimes:- i) Acidlime budlings on gajanimma, jamberi or acidlime are a little early to commence cropping and yield somewhat more than seedlings in the first 10-15 years. Thereafter, the seedlings also catch up the budlings in yield potential.

ii) As a rootstock gajanimma is more vigorous, precocious and a good yielder. Hence it ensures early returns much desired by the growers.

Since experimental results show that in general the seedling acidlime plantations fare as good as the budlings in respect of yields and disease resistance and the same is corroborated by the commercial lime growers all over the State more than 90% of the existing lime plantations in Andhra Pradesh comprise of seedlings only. The citrus nurserymen are also happy to sell seedlings overcoming the trouble of budding which is somewhat difficult due to thorny nature of limes. Slight advantages of increased vigour and higher yields in the early years particularly on gajanimma rootstock do not appear to have caught up the imagination of the shrewd lime growers as yet. Hence seedling lime plantations are more or less the general rule in the State to-day.

Lemons:- In an effort to popularise lemons as a substitute for limes, if possible, efforts were made at Kodur to grow Nepali oblong lemons on gajanimma, jamberi and

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acidlime rootstocks alongside with layers. Based on the performance over a period of 12 years of orchard life, it was concluded that gajanimma rootstock was superior in respect of yields and disease resistance.

Inspite of considerable promise exhibited by the lemons at Kodur, none of the lime growers in the State have taken to lemon on a commercial scale with the fear that marketting of lemons may pose serious problems because the consumers do not easily change their traditional habit of using lime and lime alone.

CULTURAL PRACTICES:-

Interculture:- In general intercrops like turmeric, groundnut, tobacco and vegetables are raised in the interspaces during the first 3-4 years. Since most of the citrus soils are well drained red loams, young citrus gardens are not adversely affected by excessive soil moisture conditions. However, in Eluru area in West Godavari district, intercrops like tobacco and chillies increased nematode infestations and some lime gardens had to be abandoned on that account.

The citrus growers in Andhra Pradesh invariably follow clean culture. Generally they work country plough in the interspaces soon after harvest of the crop in November--December and at other times when weeds pose problems. Such disturbance of surface soil upto about 6" depth does not appear to have any adverse effect on tree condition. Age old practice of digging a trench and pulling out portion of fibrous roots (bahar treatment) is not generally followed in Andhra Pradesh.

Manuring:- The experimental results at Kodur have shown that a good bearing citrus tree needs about 3 lb nitrogen mainly in the form of organic manures like farm yard manure and oil cakes supplemented by small quantities of ammonium sulphate or urea. However, in actual practice a majority of the citrus growers manure their citrus gardens solely with farm yard manure but adequate enough to harvest upto 1,000 fruits or more of sweet orange. In the case of acidlimes the growers generally supplement farm yard manuring with ammonium sulphate or urea in 3:1 proportion of nitrogen approximately.

Irrigation:- In Cuddapah and Anantapur districts citrus gardens suffer severe water stress due to inadequate water in the wells during drought periods. In general, soon after harvest of crop in October - December, the growers stop irrigating their gardens. They plough the land and allow the trees to come to a stage of partial wilting by about the first week of January. At that stage they manure and irrigate

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so as to get a sizeable blossom in one wave. Thereafter, the grower based on his past practical experiences irrigates the garden judiciously varying the interval and quantity of water from time to time. Double ring system of irrigation is followed by many growers.

Studies on growth regulators:- 2-4'D sprays at the dilution of 10 ppm at flowering, one month after fruit set and two and one month before harvest increased ultimate yields. It is possible that some growers take up this recommendation with advantage. Similarly spraying of 300 ppm of gibberellic acid at flowering stage increased fruit set and reduced seediness to some extent.

Disease aspect:- Prior to 1950, gummosis and zinc deficiency were the two maladies bothering the citrus growers and they had satisfactory control measures. Hence there was practically no concern among growers then. Later, root rot and early decline of citrus assumed severe proportions and ruined citrus industry.

Investigations into the causes for root-rot showed constant association of fungi like Diplodia spp., Rhizoctonia spp., and Fusarium spp. But most of these fungi were adjudged as secondary organisms following general debilitated condition of trees due to cumulative effect of defective soil, culture, nematode infestation and virus infections over a series of years of orchard life. Expert culture and best of plant protection measures did not alleviate quick decline. Zinc sulphate-lime sprays had only partial recovery while certain types of chloroses did not respond to single or multiple micronutrient sprays. As the cause of quick decline was not clearly know, thousands of sathgudi budlings and acidlime seedlings died in Kodur-Rajampet tract (which was the earlier strong hold of citrus) where growers abandoned citriculture and shifted to banana cultivation. However, inumerable number of new citrus plantations came into existence in Pulivendala, Tadpatri, Anantapur, Gudur, Kurnool and other areas. Every where gardens showed promise in early years but started declining within 5 to 10 years.

Detailed investigations carried out at the Fruit Research Station, Kodur, during 1958-'60 revealed that tristeza and other virus infections were mainly responsible for early decline. By 1966, it was further learnt that greening virus is also very much prevalent in our State and that quick decline is more due to the synergistic effect of tristeza-greening complexes. In addition, recently it is proved that citrus plantations in Andhra Pradesh are infected by infectious variegation, mosaic and necroticcorky vein disorders of virus nature not reported from other parts of India as yet.

Indexing of prospective parent citrus trees from different localities reveal that there is no likelihood of meeting with absolutely virus free parent trees in the State. This is due to the fact that commercial citrus nurseries at Kodur which cater

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to the needs of the entire State of Andhra Pradesh and adjoining States like Madras multiply plants indiscorimintely and thereby viruses spread and get perennated. Hence concerted attempts need be made to prevent indiscriminate multiplication at the nursery level. The sooner it is done the better it is for the citrus industry. This is engaging the immediate attention of the Andhra Pradesh Agricultural University, Hyderabad.

Pests:- Leaf miner is a regular nuisance whenever tender flush appears on the trees. Aphids also infest tender foliage and twigs in winter months. The scales are a serious problem particularly on lime trees in certain tracts. Mites badly discolour the Sathgudi fruit rind and thereby reduce market price. The fruit sucking moths are troublesome in rainy months particularly in Rayalaseema where basketting of fruits is not done as in circars. Psyllids appear in low intensity at times. Apart from the physical damage done by the aphids, psyllids and mites, they help in the spread of certain virus complexes and hence they need effective control in right time.

A B S T R A C T

Sathgudi on jamberi became popular by 1945. But by about 1950 early decline set in and devastated the sathgudi and acidlimes. Sathgudi on sathgudi rootstock proved good for yields, fruit quality and disease resistance at Kodur, during 1945-'60 and hence this was recommended to growers. However, as a result of multiple infection of greening, tristeza, infectious variegation, mosaic and so on presently sathgudi on sathgudi also does not appear as promising as in the past. Hence, jamberi still continues as the major rootstock in the State. In the case of limes, seedling plantations are common. Commercial lemon cultivation is not taken up in the State.

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ALL INDIA SEMINAR ON CITRICULTURE
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LATEST TRENDS IN CITRICULTURE IN ANDHRA PRADESH

By

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INTRODUCTION:

Sweet orange and acid lime are the two citrus fruits of commercial importance in Andhra Pradesh. Kichili which was largely grown in coastal area is seen sparsely at present. Pummelo, Gajanimma, lemon, citron and other species are found as stray plants in the gardens mainly for local consumption.

DISTRIBUTION:

In the past, a few gardens of sweet orange seedlings were grown in Kodur. With the establishment of Fruit Research Station, Anantharajupet, in 1935, vegetative propogation of Jamberi rootstock was introduced and as a result several nurseries sprang up around Kodur. In a few years the area under citrus buddings expanded rapidly to the other regions and present the citrus fruits occupy an area of 27,500 hectares. More than 60% is concentrated in the Rayalaseema belt 17% in Nellore zone (acid lime alone) and 15% in Godavary area.

DECLINE PROBLEM:

The sweet orange orchards planted 35 years ago in Kodur area were highly productive for three decades and then declines. The acid lime trees also lives for 25 years. The orchards of 20 years life, planted in other zones have shown signs of decline at present. The new plantations raised during the past decade are soon declining within 7 to 10 years after yielding three to four crops. However the acid lime seedlings are found to live for 15 to 20 years. The problem of citrus decline has caused a great alarm among the orchardists who are switching on to the planting of acid lime or growing other commercial crops.

Therefore a survey of gardens was undettaken along with Dr. L.C. Knorr, Citrus Virology Advisor of Florida, during September and October, 1970, to investigate into the factors contributing to this malady. The soils, water management, cultural practices were studied and the leaf samples collected from trees showing different patterns of chlorosis were analysed by the Radio Tracer Chemist, Hyderabad (Table I a & b). Experiments were carried out at the station to study the effect of micronutrient sprays on leaf chlorosis. The observations with reference to the different factors are discussed in the paper.

SLIMATE:

Provided irrigation is assured, the tropical plains, are well suited for citrus cultivation, irrespective of rainfall in the regions. The minimum temperature does not go below 15 •C normally. The virulence of the bark eruptions and canker disease on acid lime are found to increase with the humidity in the area. The acid lime plantations in the coastal regions are very much affected by these maladies due to high humidity during the major part of the year (7) while the gardens 23 and 24 in dry tracts are free free in this regard.

Attractively coloured fruits of sweet orange are produced in the comparatively drier areas, with low precipitation during the harvest period.

SOILS:

Since the citrus crop is highly remunerative it is planted in all types of soils without observing the crop requirements. Jamberi rootstock with a deep rootsystem (4) is adopted in all the regions and as a result the citrus plantation grown in shallw soils of Ananthapur district are subject to rapid decline even before tenth year (5).Ill drained conditions and alkalinity are found to agreevate leaf-mottling. Different patterns of chlorosis were observed mostly in the schallow soils indicating the micronutrient deficiencies. In deep soils, however, the chlorosis was observed sparesely in the trees while the die-back of twig and sparse foliage are the common symtoms. The trees also lived comparatively for more number of years. The leaf analysis pointed out the deficiency of the micronutrients in the eigth and twelth gardens. In general nitrogen status was poor in most of the cases and just marginal in other cases. The samples collected in first, second, sixth, seventh and eighth gardens were very low in calcium status, as a result of ill drained conditions and salinity. The zinc

status is critically low in all the cases except in Batavian and acid lime seedlings in 20th and 22nd gardens. The iron status was generally high leading to toxic levels. the P,K.Mg, Mn, Cu, and B status are optimal and do not appear to be limiting.

VARIETIES:

Sathgudi and Batavian are ecotypes largely grown. Mosambi in cultivated on a limited scale in Rayalaseema and Telangana. Seedlings of Sathgudi are found to live for 35 to 40 years, indicating the inherent tolerance of this variety to decline. Kagzilime seedlings are found to live for 20 to 25 years, even under conditions leading to decline.

ROOTSTOCKS:

The wide use of Jamberi rootstock which is highly susceptible to the greening virus is the main causes of citrus decline. In the coastal areas seedlings are preferred in both sweet orange and acid lime. As a support to the plant against cyclonic winds, mounding at the base is a common practice. The budlings on Jamberi developed collar diseases and bark peeling as a result of which the gardens declined in the past 3 years of planting.

It is very necessary to evolve rootstocks suitable for different soil conditions. In the rootstock trials conducted at Anantharajupet, Sathgudi and Billikichili rootstocks are found to be highly tolerant to decline as evidenced by the percentage of survivals in Sathgudi trees on different rootstocks in 1970 furnished below.

	Trial planted in 1938	Trial planted in 1951
Seedlings of Sathgudi	33%	100%
Sathgudi on Billikichili (Cleopatra mandarin)	17%	--
Sathgudi on Sathgudi	11%	92%
-do- Kichili	Nil	42%
-do- Jamberi	Nil	2.7%
-do- Gajanimma	Nil	--

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Rangpur lime which is found a promising root-stock in other states has been tested at this tation but 50% of the Sathgudi budlings on this root-stock have declined within three years of planting showing symptons of excortis. At present Sathgudi is recommended as the commercial rootstock. The owner of garden No. 20 expressed satisfaction regarding the performance of these plants. Gajaninma is found as the most prolific rootstock for acid lime, Pummelo and Grapefruit. Vadlapudi orange is found to be most prolific on marmalade orange (Rangapur lime - Anantharapujet). In any case, it is essential to procure budwood from seedling trees soon after they come to bearing before they contact the viruses. The long-bearing period and absence of chlorosis in garden Nos. 9 and 13, may be due to the scion wook taken from an young seedling.

WATER MANAGEMENT:

In the tropical climate for high yields irrigations at frequent intervals are necessary for citrus crops. Irrigation when the top 23 cm of the soil goes dry is recommended. During the last decade, numerous wells have been dug at short distances in the citrus growing areas resulting in poor recouperation capacity 6f the wells. Under the drought conditions prevailed in 1968 some citrus orchards had to be cut down because of water scarcity in Ananthapur and Cuddapah districts. Water in certain wells showed a pH value of more than 7.5 which might have induced sailinity in the soil and chlorosis in leaves.

The leaf chlorosis was mostly sparse in the areas with high water table, atleast during a part of the year. The phenomenal correction of chlorosis in the garden number 10 where paddy is cultivated may be due to release of micronutrients.

CULTURAL PRACTICES:

Mulching in citrus with dry leaf reduced the number of irrigations, weed growth while improving the yields yields and fruit quality. (2). In most of the gardens mulching is little practised but the basins are dug frequently to keep down the weeds which is harmful to the rootsystem. The use of Dowpon at two to four kg. per acre will be useful in combating the weeds.

Even in healthy gardens, leaf chlorosis is observed sparsely. Garden No. 14 testifies to the fact that the leaf chlorosis was completely corrected by micro-nutrient sprays. At this station, a trial with four

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replications in randomised block design was condicted to study the effect of micronutrients in reducing the leaf chlorosis in sweet orange. A combined spray of seven nutrients (Manganesse sulphate and zinc sulphate 0.25% ferrous sulphate; copper sulphate, Magnesijm sulphate, Ammonium molybdate, boric acid each at 0.1%) and omitting one of the nutrients at a time were compared in theyear 1970 and the results are furnished in table No.2.

TABLE -2.

Showing the effect of micronutrient sprays on leaf chlorosis.

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Treatment.	Mean % of chlorotic leaves Experiment-I	Experiment-II.
1. Combination of seven nutrients	9.5	10.7
2. Without zinc	36.3	33.7
3. " Iron	10.6	5.9
4. " Copper	4.1	~~1~~2.1
5. " Manganese	28.8	21.2
6. " boron	6.0	14.0
7. " molybdenum	5.3	8.2
8. " magnesium	1.2	9.2
9. Control (only water spray)	44.6	35.4
C.D. @5%	11.9	8.86

The per cent of chlorotic leaves is high when no spray was given and when zinc, manganese and boron were omitted in the nutrients indicating importance of these three nutrients for citrus in the red loamy soils. Three sprays of 2,4-Dichlorophenoxyacetic acid at 10 ppm at flowering, after fruit set and two months before harvest are recommended to increase the fruit set, reduce the fruit drop and increase the final harvest. Progressive orchardists

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are convinced of this recommendations andhave been practising in certain gardens, confirming the observations elsewhere (1,6).

MANURING :-

Application of 1.5 kg.nitrogen 1.0 kg. of P2O5 and 1.0 kg. of K2O is recomended over a basal dressing of 90 kg. of farm yard manure (2). There is a tendency among among cultivators to apply large quantities of cattle manure wherever possible and it is claimed that citrus decline is less in such cases. Studies to determine the manurial requirements of sweet orange and acid lime are in progress at this station.

HARVEST & STORAGE :

Individual trees of Sathgudi produce 1000 to 2000 fruits. Acid lime trees bears 3000 to 5000 fruits annually. Improved methods of harvest preventing the fruits from falling to ground have to be still devised. In the preliminary trials on storage of fruits, dipping them in 2 to 3% wax emulsion combined with 2,4-D 50ppm improved the storage life. In the case of acid lime, besides fruit treatment, packing in alkathene lines gunnies have further increased the storage period. The age-long methods are still in vogue and new techniques have to be brought into commercial practice.

S U M M A R Y

A survey was undertaken during 1970 to investigate the problems and latest trends in citriculture in the different citrus gardening regions in Andhra Pradesh. In the coastal regions with high humidity, acid lime orchards suffer from virulence of canker and bark eruptions. High quality fruits of sweet orange are produced in areas with low rainfall. The citrus gardens are planted without any reference to soil requirements. The trees suffer from malnutrition and severe leaf chlorosis in shallw soils of Ananthapur district. In the deep soils with a high water table the trees show sparse chlorosis but to a great extent die-back of twigs and sparse foliage. Calcium and nitrogen were found low in most of the soils. Iron toxicity is observed. Sprays of zinc, manganese and boron are found to reduce the chlorosis.

Sathgudi seedlings are found highly tolerant to decline. Cleopatra mandarin and Sathgudi are recommended

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as decline tolerant rootstocks for other species. It is suggested to draw bud-wood from young bearing trees apparently free from virus disease. Frequent deep digging in citrus besins is deprecated. Manuring at 1.5 kg. N, 1kg. of P_2O_5 and K_2O each is recommended besides application of 90 kg. of farm yard manure. Three sprays of 2,4-D 10 ppm at flowering after fruit set and two months before harvest are found to foster high yields. Frequent irrigations and mulching favour better yields.

ACKNOWLEDGEMENTS

Acknowledgements are due to Andhra Pradesh Agricultural University for providing facilities in conducting the survey of gardens along with Dr. L.C. Knorr, the citrus virology adviser of Florida and also carrying out experiments at this Station. Thanks are due to Dr. J. Venkateswarulu, Radio tracer Chemist who conducted the chemical analysis of leaves.

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T A B L E -1(a).

Showing the particulars of gardens surveyed

Garden No.	Place, cultivators' Name.	Soil type	Water table (Metres).	Variety	Age in years	Garden No.	Remarks
1.	2.	3.	4.	5.	6.	7.	8.
Kurnool District:							
1.	Panyam Shri K.V. Giri Ral	Black loam deep	4.5	S/J	10	1	One tree developed severe mottling, cupping and stiffening of leaves. In another tree the foliage sparse with sparse mottling of leaves and specks on branches. Two lines of trees under ill-drained conditions exhibited leaf chlorosis.
2.	Deepaguntla Shri T.Babul Reddy	-do-	-do-	S/J & M/J	8	2	During rainy season water tables rises to 1 m. below ground level due to paddy cultivation round about. In general chlorosis of leaves less in the trees but one tree in extreme corner under ill drained soil conditions developed severe mottling.
3.	Govindappale Sri G. Narapa Reddy	-do- ill drained.	-do-	S/J	20	3	Sparse foliage; dieback of twigs; scaling of bark common Even now the trees bear 400 fruits on average; cultivation neglected.

1.	2.	3.	4.	5.	6.	7.	8.
4.	Chagalamarri Sri P. Narasimhulu	Red Loam shallow (1 metre)	2 to 3.00	S/J	18	4	Mottling slight; die-back of twigs seen; Yields good.
	Ananthapur District:						
5.	Kalasamudram Sri K.V. Narayana	Red Sandy loam.	4.5	S/J	8	5	Some trees put on complete mottled appearence and produce flowers but not set fruits. In some trees few branches mottled. Besides virus infection, the trees showed malnutrition. Just by its side, trees in another 12-year old garden are very healthy.
6.	Dorigella Shri D.V.R. Reddy	Red Loam Shallow (1.5 m.)	3 to 4.5	S/J	12	6	Most of the trees sparsely chlorotic and yields reduced. Some trees stunted & severely affected with chlorosis and produce no fruit.
7.	Dorigella Sri T.V. Siva Reddy	Deep red Loam deposited soil.	4.5	S/S	30	7	Trees healthy; slighly chlorotic but die-back of twigs severe - cultivation neglected.

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1.	2.	3.	4.	5.	6.	7.	8.
8.	Mukkarayasamudram Sri B. Narayanappa	Deep red loam	2.0	S/J &	8	8	Tristeza symptoms, slight bark erruptions, bark splitting observed in acid lime. In Sathgudic trees both healthy and chlorotic branches observed; cupping ofterminal leaves; cultivation neglected.
9.	Varadayapalli Sri B. Rangappa	Black loam	4.5	S/J	11	8	The trees come to bearing in the seventh year and are vigorous, producing heavy yields. Sparse leaf mottling observed, no dieback.
10.	Mukkarajusamudram Sri M. Lakabamma	Red loam	2.0	S/J	8	10	In one tree, most of the leaves developed characterestic yellow specks, while a few show interveinel chlorosis Most of the trees turned completely chlorotic. The owner has been growing paddy in the interspaces for one season during the last five years and found that the chlorosis was corrected and the trees began giving fruits again.
11.	Paravali Shri K.Kondappa	Black sady loam deep.	9.0	S & M/J	7	11	Most of the trees sparsely chlorotic; some newly planted [illegible] year old trees have [illegible] chlorotic already.

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1.	2.	3.	4.	5.	6.	7.	8.
12.	Ananthapur Sri A.S. Reddy	Red Loam under lined with a hard pan ill drained.	4.5	S/J	6	12	The trees are sickly. In one tree a bottle neck was formed at the bud union with gum exudation. The leaves almost white with green spots; the fruits ill developed and dropped. The rind showed gumming; In other trees chlorosis is sparse; but leafless shoots with multiple buds common. In some trees leafes with round spots surrounded by yellow hallow abserved Cultivation neglected.
13.	Koravaripalli Sri Y.N.S. Setty.	Red Alkaline.	6.0	S/J	8	13	The trees came to bearing in the eighth year. Out of 100, two plants are sickly with chlorotic leaves and the rest are quite healthy with deep green foliage. Cultivation: neglected.
	<u>Cuddapah District.</u>						
14.	Pulivendala Sri R. Somi Reddy	Black soil deep 1.0m	6.0	S/J	15	14	The trees are robust and in good condition. The chlorosis of leaves was corrected with nutritional sprays. Now the trees have die-back of twigs and sparse foliage. In some trees blackening of bark and gumming of branches observed. In certain plants woody galls were noticed below the bud joints. In another plot, some of the five year old plants developed severe chlorotic symptoms.

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1.	2.	3.	4.	5.	6.	7.	8.
15.	Nallapareddy Palli Sri P.V. Subbaiah	Red Loam 0.5m deep underlaid with moorum.	5.0	S/J	9	15	Most of the plants affected with severe chlorosis and zinc; sprays did not relieve. In one basing, two trees were planted out of which one is affected severely with chlorosis while the other is healthy. This shows the nontransmission of greening without insect vectors, Diaphorina citri, which is not observed in the citrus growing regions except Kodur area.
	Nellore District:						
16.	Venkatagiri Sri T. Mallaiah	Red Loam	4.5	A.S.	12	16	Five plants of acid lime are in declining stage. The bark showed inverse stem pittings and bark eruptions are very common on the branches. Bark splitting and gumming observed which is reported to be an indication of declining.
17.	Bangarupeta Sri B. Munaiah	-do-	3.0	-do- A/J	11	17	Some of the plants declined. Bark eruption are commonly observed; One tree of Gajanimma of same age is in good bearing; cultivation: Good.
18.	Chennur Sri K.K. Reddy	-do-	3.0	A.S.	20	18	The orchards is in severe decline conditions. [illegible] another plantation [illegible] in good bearing [illegible] severe Cultivation: Neglected.

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1.	2.	3.	4.	5.	6.	7.	8.
	Guntur District:						
19.	Bapatla Agricultural College Farm	Sandy	3.0	A.S.	18	19	The acid lime seedlings of 18 years age are in declining conditions. Bark eruptions, bark apitting and tristeza symptoms are severe. In the Kichili trees of 19 years age sparse chlorosis observed. Leaf miner incidence is heavy. During rainy season the water table raises to ground level. The water four metres below the ground level is brackish and not fit for irrigation.
	West Godavary District:						
20.	Throvaguntla Sri J.S. Rao.	Dead Red Sandy Loam deep.	4.5	a) B.S. b) S/S c) B.S. d) -do-	8 8 30 22	20.	The Batavian seedlings have slight chlorosis of leaves. The Sathgudi trees on Sathgudi rootstock are performing well Batavian seedlings planted in 1932 are still surviving and are suffering from more dieback rather than chlorosis. Nematode galls are observed on the roots of the seedlings trees. The 22 year old seedlings are quite healthy.
21.	Thodimella Shri P.A. Ramaiah.	-do- ill-drained.	4.5	a) B.S b) B/J	20 20	21.	The budded plants developed collor-rot soon after two years of planting and hence seedlings trees were planted near them and budded plants grubbed out. A few of these are still surviving. Chlorosis is sprasely observed in this garden. Dieback of twigs and sparse folliage are common features.

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1.	2.	3.	4.	5.	6.	7.	8.
22.	Peddavegi Dr. M.J. Raju	Deep Red Sandy loam ill drained.	4.5	a) B.S. b) B/J c) A.S. d) K.S.	8 15 15	22	The acidlime seedling trees are in declining stage, showing severe symptoms of bark eruptions and dieback. They are interplanted with young seedlings. One five year old plant develop ring spots in leaves which were collected for analysis. Big earthen mounds are erected at collar portion to guard against cyclone damage. Fifteen year old Batavian budlings on Jamberi are declining due to dieback of twigs. Batavin seedlings of eitht years age are not showing chlorosis and are healthy, cultivation neglected.
	Warangal District:						
23.	Yellapur Sri G.G. Reddy	Deep red loam	9.0	a) A.S. b) S/J	15 15	23.	The sweet orange leaves are lustrous but bark splitting and gumming at the base is commonly found. Some of the trees flower profusely and produce narrow leaves and wilt suddenly. In most cases dieback of twigs is observed. On acid lime tree no bark eruptions are seen.

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1.	2.	3.	4.	5.	6.	7.	8.
24.	Dharmasagar Sri R.V. Reddy.	Sandy loam	9.0	a) S/J b) A/J	4 8	24.	Some sweet orange plants are severely affected with chlorosis and narrow leaves and are stunted in growth. Canker is sparsely observed but not bark eruptions. Delayed irrigation in one block caused stunted growth of plants. Being in the vicinity of a big tank, during rains water comes up to ground level.

S. : Sathgudi
S.S. : Sathgudi seedlings.
A.S. : Acid lime seedlings.
A. : Acid lime.
M. : Mosambi

B. : Batavian.
R.S. : Batavian seedlings.
J. : Jamberi.
K.S. : Kichili seedlings.

TABLE - I(b)

Showing the results of analysis of citrus leaf samples.

S. No.	Garden No.	Variety	Symptoms observed	Percentage on oven dry basis					ppm on oven dry basis				
				N	P	K	Ca	Mg	Fe	Mn	Cu	En	B
1.	1(a)	Sathgudi on Jamberi	Severe mottling, leaf cupping & stiffening.	1.84	0.186	2.91	1.30	0.40	290	30	7.2	7.0	150
2.	1(b)	-do-	Severe mottling; tree sickly.	2.10	0.193	2.48	1.50	0.60	490	28	9.4	18.0	140
3.	2	-do-	Severe mottling, stunted trowth of plant.	2.34	0.143	1.70	2.10	0.87	320	45	6.1	10.0	200
4.	8	-do-	Chlorotic and healthy leaves on the s ame tree-terminal leaves cupping.	2.20	0.127	1.45	2.45	0.80	230	30	8.3	3.4	120
5.	10	-do-	Leaves with yellow specks, some with interveinal chlorosis.	2.30	0.182	2.04	2.30	0.72	260	23	13.8	8.9	200
6.	12	-do-	Leaves witish with green spots fruits ill developed.	2.10	0.160	2.00	1.40	0.40	160	26	9.4	6.1	150
7.	22	Acid lime	Yellow ring spots-stray stem pittings and bark eruptions.	2.10	0.320	2.82	1.70	0.63	230	23	9.4	19.4	70
8.	21	Batavian seedlings.	Leaf chlorosis sprase	2.24	1.182	2.91	1.45	0.40	300	30	11.1	16.7	110

ABSTRACT

The survey of citrus gardens, revealed that not much attention is bestowed to cultivation of citrus fruits. The sweet orange trees planted in shallow soils are found to suffer with malnutrition and chlorosis of different patterns. In deep soils, die-back of twigs is common with sparse chlorosis. Calcium, nitrogen and zinc are particularly low in most of the trees. Sprays of zinc, manganes and boron corrected the chlorosis. In Humid zones, the acid lime is severely effected with canker and bark eruptions. Sathgudi seedlings are found highly tolerant to decline. Cleopatra mandarin and Sathgudi are recommended as decline tolerant rootstocks of Sathgudi. Gajanimma is a prolific rootstock for other species. Manuring at 1.5 kg. N, 1.0 kg. each of P_2O_5 and K_2O besides 90 kg. farm yard manure is recommended. Frequent irrigations and mulching favour between yields. Three sprays of 2,4-D 10 ppm foster high yields.

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Item No. 1(i)

ALL INDIA SEMINAR ON CITRICULTURE
NAGPUR - 1972

REVIEW OF CITRUS INDUSTRY IN MYSORE STATE

By

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&

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In recent years the importance of fruits and vegetables in the economy of the country during this crucial time of food crisis has been felt very much and the Government of Mysore, have fully realised this problem in order to ease the burden on cereals and millets.

Citrus occupies a very important place among the commercial fruits in India. They are the sources of Vit. C., minerals, certain fruit sugars and salts which constitute important health promoting ingredients in the human diet. They possess sufficient medicinal value too. The present estimated area under citrus in India is about 1,05,396 hectares and the total production being roughly 1.2 million tonnes (Survey of India's Export Potential for fruits and vegetables 1968). Mysore State is one of the major citrus producing areas like other states such as Andhra Pradesh, Maharashtra and Punjab. Among the fruit crops grown in Mysore State, citrus is next to Banana in area. It is estimated that the present total area under different citrus varieties is about 50,560 acres (20,426 hectares) in the State. The important citrus growing districts in Mysore State are: Coorg, Hassan, Chickmagalur for mandarins, Dharwar, Kolar, Mysore, Shimoga, Tumkur, Bijapur, Bangalore, Bidar for Sweet Oranges and Limes. In the following table districtwise areas under citrus is included.

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Acreage of Citrus in Mysore State - 1967-68
(Districtwise)

Sl. No.	District	Area	Citrus varieties grown
1.	Bidar	335 acres	Sweet orange, Limes.
2.	Bijapur	1020 "	Limes, Sweet oranges.
3.	Belgaum	148 "	Sweet oranges, Limes.
4.	Bellary	341 "	-do-
5.	Bangalore	500 "	-do-
6.	Coorg	40000 "	Mandarins, Lime, Sour Oranges, Lemons and Sweet Oranges.
7.	Chickmagalur	2870 "	-do-
8.	Chitradurga	277 "	Sweet oranges, Limes and Lemons.
9.	Dharwar	303 "	-do-
10.	Gulbarga	250 "	-do-
11.	Hassan	2351 "	Mandarins, Sweet Oranges and Limes.
12.	Kolar	267 "	Sweet oranges, Lime.
13.	Mandya	109 "	-do-
14.	Mysore	282 "	Sweet Oranges, Mandarins, Limes, Lemons.
15.	N. Kanara	150 "	Limes, Sweet Oranges.
16.	Raichur	198 "	Sweet oranges, Limes.
17.	Shimoga	574 "	Sweet Oranges, Mandarins, Limes, Lemons.
18.	S. Kanara	30 "	Limes, Lemons, Sweet Oranges.
19.	Tumkur	456 "	Limes, Sweet Oranges, Lemons.
	Total	50560 acres	

Soil Conditions:

The soils of citrus growing areas in Coorg, Hassan and Chickmagalur ranges from red latritic loams to medium clay loams to black clayey soils. The soil pH ranges 5.5 to 6.5. The findings of the root study at Citrus Die-back Station, Gonicoppal, suggest that the selection of a deep and fertile soil is essential for citrus. In Mysore State, mandarins are grown in

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areas where the temperature ranges from 45° - 95°F and at the elevation between 450-1000 metres. The rainfall in these citrus regions (Coorg, Hassan, Chickmagalur) vary between 100-250 Cms. In these tracts mandarins are grown under rainfed condition. In areas where sweet oranges are grown, the temperature ranges from 85° - 110°F and the rainfall ranges between 25 cms to 75 cms per annum and in these parts, citrus is being grown under irrigated conditions.

Varieties:

Commercial varieties under mandarins chiefly is Coorg Orange which occupy an area of about 45,000 acres in three Districts of Coorg, Hassan and Chickmagalur. A new introduction of the citrus station, Gonicoppal, called Unshiu, a seedless satsuma mandarin is becoming popular among the growers. In the Sweet orange varieties the Sathgudi oranges in Kolar, Bellary, Bangalore, Bidar areas and Mosambi oranges in Dharwar and Belgaum areas are popularly grown to some extent. Other citrus fruits are Kaghzi lime which is commercially grown in Tumkur, Bijapur. At Gonicoppal and Chettahally centres, we have a rich collection of about 290 citrus varieties and species. Among these introductions Washington Navel, Valencia, Pineapple orange, Bibile seedless have quite promising prospects.

Rootstocks:

In Mysore State, especially in mandarin growing areas, citrus is grown with seedlings from time immemorial. But in recent years, the investigations conducted at Gonicoppal and Chettahalli centres have revealed that out of 81 rootstocks certain rootstocks such as Rough Lemon (C. Jambhiri) Rangpur lime (C.Limonia), Kodakithuli (C.reticulata), Poncirus trifoliata, and Cleopatra mandarin (C.reticulata), have been found to be suitable for mandarins with respect to resistance to die-back condition, root rot troubles and also for betteryields. After sufficient years of observation on these performing rootstocks, the same have been released to the growers. Now we are supplying to the tune of about 30,000 to 50,000 budlings of mandarins annually to the cultivators from our departmental nurseries. The rootstocks Sour oranges, Acid lime, Lemon, Lime Sadhaphal, Pummelo, Grape fruit and Citron have been proved to be a failure.

Cultural Practices:

Although in earlier periods majority of the growers adopted intercropping with Coffee, giving sufficient spacing between the trees to avoid root competition, now they are gradually taking up pure plantations of citrus adopting all the technical advices of the Gonicoppal and Chettahalli Stations, after considering the benefits of the pure orange plantations as evident from these two model stations. Now there are about 1500 acres under pure plantation of citrus in the State and the area is expected to

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increase in the future. Under cultural practices, the growers adopt the techniques that are followed in our departmental stations. Pit size is generally 60 x 60 x 60 Cms to 75 x 75 x 75 cms and spacing between plants is $6\frac{1}{2}$ x $6\frac{1}{2}$ metres in case of mandarins and sweet oranges. In case of dwarfing rootstock like Trifoliates spacing of 5 x 5 Metres is being recommended . While planting limes and lemons the spacing given is 4 x 4 to 5 x 5 metres. Soon after planting the plants are supported by staking and some grass mulch is provided and watered copiously if no rains are received immediately after planting.

During the first year of planting a deep digging to a depth of about $1\frac{1}{2}$' is given to remove all the tree stumps, stones and jungle tree roots and also to give a good tilth for sufficient soil areation and for proper root development. Shade trees are occassionally provided in less rainfall tracts, at the border, at a distance of 30-40 metres from one another to check the strong winds and to provide sufficient humidity and shade in the orchard. When the plants are young, training or trimming is given by removing the lower branches or shoots to maintain, single stem upto a height of about 45-60 cms and then to allow branching without much overcrowding to give a good shape and strong frame work.

Weeding is the important and costly operations in malnad regions during monsoon season. Usually 4-5 weedings by Dabba (or weeding knife) are done from May to October and finally the entire area is scrapped and such scrapped weeds or grass are used as mulches around the tree basin, to conserve moisture. Findings of the experiments conducted at Gonicoppal centre have already revealed the importance of mulching during summer or drought period in reducing dieback condition.

After 2-3 years of planting, generally no digging is given to soil except shallow scuffling to a depth of 7-10 cms at the time of incorporating manures and fertilizers. The rootstudy work conducted at Gonicoppal have shown that about 66% of the thick and delicate roots are found within the depth 0-30 cms from the ground level and hence deep digging may cause root damage and injury.

Pruning of dried twigs, water shoots and dead branches is done once in a year regularly to give a rejuvinated look and to stimulate vigorous growth in matured trees. Pruning is done after harvesting the crop during January-February.

Manuring and Fertilization:

Our citrus growers are manure-conscious and they take up manuring and fertilization in consultation with the departmental staff. Before embarking on fertilization, they get their soils analysed at the departmental soil testing laboratories for various macro-and micro-nutrients and also for soil pH. In

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mature orchards the plant nutrients are given to supply approximately 0.55 Kg N, 0.37 kg P_2O_5 and 0.55 kg K_2O per tree per annum in 2-3 split doses. Micro-nutrients like Zn, Cu, Mn, Mg are given in the form of Sulphates in neutral solutions (using spraying lime) once in a year as a regular orchard practice during new flush periods (April-May or September-October). Findings of the micro-nutrient trials at Gonicoppal have indicated that plant nutrition with micro-nutrients is quite essential for sucessful citrus cultivation. The studies revealed that importance of Zinc, Manganese and Magnesium in soils in some parts of Mysore State and beneficial effects of these elements by foliar application has been observed.

Plant Protection:

Since proper plant protection measures constitute one of the important items of scientific growing of citrus, our orchardists adopt timely preventive and control measures against various pests and diseases in consultation with our departmental staff. We have a separate division of plant protection with Headquarters at Bangalore to cater to the needs of fruit growers in providing timely plant protection measures.

The orchard appriasal work conducted by the Gonicoppal centre have shown that certain insect pests and diseases are important and the growers are now becoming conscious in taking up all care and plant protection measures for their orchard trees. Among the diseases leaf fall and fruit rot caused by Phytophthora palmivora, Roots stump-rot and gummosis caused by Phytophthora sp. Diplodia sp. Fusarium sp. are very important. Among pests stem borer, Aphids, Mites, Scales and Psylla are found very important in our tracts in Mysore State. Proper control measures are being worked out at Gonicoppal and Chettahalli centres and accordingly we are giving timely technical guidance on plant protection measures to the growers.

Orchard management:

The citrus growers in our tracts are becoming more scientific in their approach to citrus orchards. Now they are adopting the techniques of scientific growing of citrus that are being recommended from time to time from the stations. The growers are taking care in respect of site selection, planting genuine and quality plants, proper care of young orchards, adopting timely plant protection measures, pruning, irrigation fertilization, micro-nutrient sprays, regular bordeaux pasting etc., while taking up orcharding.

Citrus development programmes:

Apart from two main citrus stations like Gonicoppal and Chettahalli centres, our department is having number of horticultural farms where different citrus varieties released from the

above stations for popularisation, are planted and put under regular observations for their performances and adaptability in the districts, especially in Raichur, Bellary, Chitradurga and Gulbarga for Sweet Orange varieties and Seedless limes, Recently Unshiu and Kinnow mandarins have also been planted in these farms for future performance and multiplication.

(a) Orange Refinance Scheme:

An Orange Development loan scheme financed by both State and A.R.C. was launched in the year 1968 with an outlay of Rs.60 lakhs (15 lakhsby State plus 45 lakhs by A.R.C.) to offer financial assistance to the growers who wish to take up mandarin orange growing on pure scientific lines based on the recommendations of our station's. This scheme caters to the needs of growers in three districts namely Coorg, Hassan and Chickmagalur and has envisaged to achieve the target of 3000 acres. Under this scheme so far an area of about 1,800 acres have been brought under cultivation. The loan is offered @ Rs. 2000/- acre.

Now, there is an awakening among the growers that citrus industry would be a profitable enterprise if pure plantations are taken up on the scientific lines. In Mysore State, there is a vast potentiality to expand the area under citrus and to foster greater citrus production.

(b) Fruit Development Scheme:

Under the Fruit Development Scheme financed by the State nearly 30,000 to 40,000 budlings and about 2 lakh seedlings are being distributed to the growers annually. These citrus nurseries are raised on scientific lines and quality plants are supplied to the growers. There are about 8 citrus nurseries in the state catering to the needs of the Growers.

Marketing and Export Potential:

The machinery for marketing of citrus fruits is not properly organised. It is estimated that about 70-80% of the total production are being marketed through the agencies of middlemen and only about 20-30% through marketing societies or other organisations. As a result the growers are not realising remunerative returns. Lack of cold storage facilities and refrigerated transport system seem to be one of the draw-backs for the Co-operatives to deal with marketing of citrus fruits successfully on a large scale.

The successful trial shipment of Coorg mandarins (5 tonnes) to Singapur during 1970-71 have opened up a new avenue for exporting of mandarins to South East Asian countries. This year (1971-72), we have a plan to export about 300 tonnes of mandarins from Mysore State (Coorg) to Singapur and other countries through the S.T.C. and Banana Corporation Ltd. There is good export potential for citrus fruits in Mysore State.

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Processing and Utilization:

There is lot of scope for processing and for proper utilization of surplus citrus fruits in Mysore State. There exist glut in the markets atmany occasions and the growers experience loss. Proper grading and packing will have to be organised well and all the surplus fruits and also the low grade fruits should be subjected for processing. To alleviate the growers from such losses, three large fruit processing factories have been opened in recent years in Mysore State (2 in Coorg, 1 at Sirsi) and they have gone into production. Along with other fruits it is envisaged that a large quantity of citrus fruits will be consumed, utilizing them into various products such as juices, squashes, cordials, canned segments, jams etc., in these factories.

Problems of Citrus Decline:

About 2-3 decades ago, the citrus Industry in Mysore State particularly in Coorg was threatened by a malady known as Citrus decline or die-back which was reported in other citrus growing tracts as well. The establishment of Citrus Die-back Station at Gonicoppal, Mysore State sponsored by I.C.A.R., New Delhi as one of the 3 centres, in the year 1954 have given a hope to the growers to combat the malady at this station. The problem is being tackled from different angles such as Nutritional, Cultural, Pathological (including virus) Entomological (Including Nemetodes) Rootstocks, root distribution studies, citrus varietal introductions, etc.

After 15 years of investigations certain valuable findings have emerged from the Station such as:-

In the rootstock studies, among 81 rootstocks under observation for Coorg mandarin, the rootstocks Rough lemon, Kodakithuli, Cleopatra mandarin, Poncirus trifoliata have been found quite suitable and trees on these performing stocks have shown resistance to tree decline condition and better yielding capacity, precocity in bearing etc.

In the orchard practices trial, mulching the tree basin with dried leaves has reduced chlorosis and dieback symptoms comparatively.

In the nutritional studies, data have been gathered from 8 years soil and leaf analysis work to study the status of macro and micro nutrients in healthy mandarin trees and their ranges have been evaluated. Spray trials with micronutrients have revealed beneficial response with elements like Sinc, Manganese, Magnesium and Copper.

It root distribution studies data from 1½ year old upto 11½ year old trees on aspects such as lateral root spread, tap root penetration, quantities of different root components etc. have been gathered and their findings have suggested for the

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re-orientation of the various conventional orchard practices. The works on other aspects are in progress. Now it is found that die-back is not due to a single factor but due to many. Therefore it is hoped that a Coordinated multidisciplinary approach to the problem may help considerably.

Conclusion and Suggestions:

On citrus, much work has been done especially on citrus decline problem at Gonicoppal and Chettahalli in Mysore State. These stations have became main centre for citrus works in the country and the various findings of these two stations have emerged into package of practices such as proper site selection, raising of genuine and disease free plants, use of nucellar plant materials, use of proper rootstocks, after care of young orchards with judicious irrigation, proper plant nutrition (both macro and micro-nutrients), control measures against pest and diseases, micro-nutrient sprays, utility of soil and leaf analysis for better orcharding and fertilization, practice of bordeaux pesting against stump and root rot etc., throughout the citrus growing areas. They are being adopted in other departmental farms in the State. The response of the trees to these package of practices are encouraging and being watched.

It can be said that on the whole, the citrus industry in Mysore State is on a sound footing except for certain bottlenecks such as marketing aspect for which, our State should take immediate steps in proper organisation of marketing and export. It is suggested that aiming at increased production in citrus out-put, will be of not much use, unless the parallel problems of handling, grading, packaging, transport, storage and marketing are adequately considered simultaneously.

ABSTRACT

Fruits and Vegetables have their own value in promoting the interests of entire mankind in many ways. Mysore State being one of the pioneer in fostering the Horticultural activities, has fully recognised the importance of the citrus industry of the State and is endeavouring to achieve the objectives of this industry in order to revitalise the economy of the growers and the state, by way of tackling the various problems confronting to the growth and expansion of this industry in particular and Horticulture in general. The two of our state Horticultural stations Gonicoppal and Chettahalli are doing pioneering work in citrus rootstock investigations, root distribution studies, soil and plant part analysis work, micro nutrient studies, plant protection work (including virus and nematode studies) etc.,. They not only cater to the needs of the state but also to other parts of the country. Their findings which have emerged into package of practices possess a great importance.

The Horticultural Farms and fruit nurseries in our state are also endeavouring to build up good and genuine citrus plant materials that can become adoptable to local soil and climatic conditions and for future popularisation. The progress of Orange Re-finance Scheme and the role of Co-operative Organisation in marketing and processing of fruits and export potential of citrus in State have been dealt with.

The area, production, cultural aspects, fertilization, marketing and utilization of citrus fruits of the state have been enunciated.

Item No. ~~13 (V)~~ 1(J)

THE PROGRESS AND DECLINE OF "CITRUS" IN TAMILNADU

By

J.S.SUNDARARAJ, STATE HORTICULTURIST, TAMILNADU

INTRODUCTION:

Tamil Nadu has a hoary past in respect of production of wide range of horticultural crops. Its situation in the tropical belt is such as to ensure the absence of rigorous summer and winter, a hazard that has delimited the range of crops that could be grown with success in other parts of the country. Although the state is mostly composed of plains, there are, dotted over the entire landscape, hill ranges which offer a vast range of agro-climatic patterns ideal to grow humid tropical, sub-tropical, warm temperate and temperate plants, thus affording scope for the cultivation of a great variety of plants. These features have helped to introduce from all ports of the world a vast multitude of plants for testing them for commercial growing. For nearly 120 years these introductions have been going on. Some of the best exotic fruits like mangosteen, Mandarin, grapefruit etc., have been stablised in this manner in several regions of the State. Almost the first attempt at some organised research on horticulture, came through these introductions, the first record of which dates back to the year 1848. This resulted in the establishment of a large number of horticultural varieties on the famous "Blue Mountain" hills. These include temperate fruits like apple, pear, strawberry etc., humid tropical fruits like mangosteen, mandarin, spices etc. Along with these basic introductions, basic research work on these crops were started in six centres situated at varying elevations on the "Blue Mountain" (Nilagiri Hills). These include perhaps the oldest of agricultural centres in the country viz. the Government Botanic Gardens established in 1848. This was followed by a research centre at Burliar located at an elevation of 2500 feet in 1870. In early 1900, the other centres came into being. Mention is to be made of Kallar Fruit Station at foot hills of Nilgiris at an elevation of 1500'. It is here that different varieties of citrus, including Mandarins and grapefruit were introducted. Extensive plantations of Mandarins came into picture in the hill ranges of Nilgiris, Palanis, Shevroys etc. The "Citrus" though a native of South East Asia, a great range of types, from wild to cultivated, were found in India. According to Tanaka (1937) India is the home of the vast majority of citrus species of the world. India has been the home of very extensive range of tropical fruits including Citrus and has been rightly said by Wilson Popenoe, the American Explorer, the world's richest sources of fruits exist in Tropical East. India, inspite of this back ground, as in the feature in all horticulturally undeveloped countries, has not yet made an impressive start on this

bristles with complications because of occurrence of bud-sports, natural hybrids etc. The international authorities on citrus classifications viz. Swingle and Tanaka do not see eye to eye on the botanical status of the several distinct species of citrus. It is well known that citrus plays an important role in the economies of several countries being one of the major fruits in horticulture. The art of citriculture remained mostly a speculative enterprise in this country for several decades. The interest of this State (Composite State) in horticultural development actually dates back to 1871, when a standing orchard at Burliar on the slopes of Nilgiris was taken for opening a Fruit Station. In the years 1871 and 1900 two important fruit centres were established and these now possess what may be called even under the present standards a unique collection of tropical and sub-tropical fruit material mostly from Asia. During the later part of the present century the horticultural research came to be intensified, mainly with a view to improve the then unorganised and mostly unscientific methods that had persisted from the past. Simultaneously newer avenues were explored to expand the horticultural crop production on sound lines to cater to the needs of the people and to augument the subsidiary food resources. An organised Fruit Research Section was initiated in Madras State in 1935, with the establishment of Fruit Research Station, Kodur in the heart of the fruit belt of Royalaseema of present Andhra Pradesh under the illustrious leadership of Dr. K.C. Naik, the present Vice Chancellor of the Agricultural University of Bangalore. This centre was pioneer in introducing and testing different species of citrus in South India. Simultaneously detailed studies were undertaken at Kallar Fruit Station, Agricultural Research Station, Wyanad and Talliparamba (Present Kerala) on sweet oranges, mandarins, limes, pummeloes, grapefruit etc. To tackle problems of an indigenous type of orange of commercial importance viz. Vadlapudi orange (_O.mo dera-spatana_) of circars (Andhra Pradesh) a seperate scheme was initiated to evaluate the pathological causes as well as to improve crop development by better horticultural techniques. The reorganisation of the states, resulted in the formation of Tamilnadu, losing the premier Fruit Research Station and other horticultural centres to present Andhra Pradesh and Kerala State. A great void was thus created in tropical fruit research, particularly in citrus, which ultimately lead to the establishment of Regional Fruit Research Station at Periyakulam of Madurai District in the year 1957, where intensive studies were undertaken in three major fruits, citrus, mango and grapevine, taking into account the success and failures, omissions and commissions faced in the earlier studies at Kodur. A mention has to be made in this context that the dreaded disease generally termed for convenience as "Die-back" showed its ugly head in the Indian sub-continent as reported by Bhatt (1945), Naik (1948) Marudarajan (1949) and Mukerjee

(1949). The Indian Council of Agricultural Research took cognaisance of this intriguing problem on a systematic basis and set afoot a coordinated scheme for investigation into causes of citrus die-back in centres dealing in citrus distributed all over the union. The Madras State took note of this dreaded disease as early as 1945 and investigations were undertaken in close colaboration with the pathoogists of the department, in Fruit Research Stations, Kodur on Sathgudi oranges, the leading commercial variety among tight skinned oranges of South India, while at Fruit Research Station, Kallar and Agricultural Research Station, Wyanad on Kukal and Wyr oranges (Mandarins), varieties grown on plantations scale in sub-tropical hill ranges of Tamil Nadu. Simultaneously elaborate laboratory studies were undertaken at Agricultural College and Research Institute, Coimbatore, extending to field studies in several private holding in representative citrus growing regions, in collaboration with Pathologist, Virologist and Horticulturist. The problem became so intense that a leading grower of citrus in Tirunelveli District offiered land and plant material and placed at the disposal of the above research body to conduct investigation on the above problem. Virus and nematodes too contributed to the decline of citrus and the respective faculties were established at Agricultural College and Research Institute, Coimbatore which also collaborated in the above investigations. At present in Tamil Nadu the work is in progress at Fruit Research Station, Periyakulam, Tamil Nadu Agricultural University, Coimbatore and Fruit Research Station, Kallar so far citrus is concerned.

II. WORK DONE SO FAR:

a) Horticultural Aspect:

As indicated earlier, poineering work was undertaken at Kodur in citrus. Several varieties and kinds were introduced from this country as well as abroad for testing their merits, insolation of superior performers and distribution of the same for extended cultivation. The notable was the local "Sathgudi" orange, which recorded a very high rank when exhibited at the International Horticultural Congress held at Berlin in 1938. This orange owes its origin to the village "Sathgur" in North Arcot District of Tamil Nadu But the intensive culture and improvement were noticed in the early stages in Royalaseema (Andhra Pradesh). Detailed descriptions of all types and species occuring in South India were made at Fruit Research Station, Kodur to streamline the nomenclature. Of the serveral methods of vegetative propagation tried, none proved to be so convenient and useful as the method of "Shield budding". Propagation by seed was the rule earlier and with the finding of an elegant method of propagation, "Shield-budding", vegetative propagation came to stay, resulting in mushroom growth of innumerable private nursories, in and

around Kodur.

Elaborate work was also undertaken at Fruit Research Station, Kodur and Periyakulam to determine the optimum rootstock for citrus fruits viz., Sathgudi and acidlime. Sweet orange on sweet orange has proved to be the most compatible combination. Similarly for acidlime, the rootstock of acid lime was more compatible, while rough lemon produced vigorous trees. Gajanimma, used as a rootstock produced heavy crops in acidlime but the trees were susceptible to the incidence of die-back and wither tip diseases. Subsequent investigations revealed that acidlime seedlings were better material for orchard planting than budded plants. In respect of mandarins, Jambori and local mandarin seedlings proved suitable rootstocks. In acidlimes, the leading commercial variety is Kagzilime, which still holds the field. As many as 16 tyres of lemons, indigenous and foreign were tested. Malta, Sevillee and Nepali lemons were isolated as best performers, exhibiting precocious and prolific bearing with certain amount of resistance to "Canker" and yielding crops alround the year. Inspite of the above economic traits and vigorous drive by the department of Agriculture, under the leadership of Late M.S. Sivaraman, I.C.S., the lemons never made any headway as a plantation crop nor could replace Acidlime which caters to the peculiar palate of Tamil Nadu. At best, it is found in kitchen gardens or mixed orchards, pure plantations being rare. A few promising types of pummeloes were isolated and this too finds a place in kitchen garden only. Optimum cultural practices in spacing, manuring etc., have been spelt out for different citrus sp. grown in this state. Hybridisation work undertaken at Kodur and Kallar did not yield any tangible results. In the extended field trials laid out at Regional Fruit Research Station, Periyakulam, the virus-fungus complex contributing to the decline of citrus was taken cognaisance of and the experimental plant materials in rootstock and scions in respect of sweet orange and Acidlime investigations, nucellar progenies were solely deployed to entirely eliminate the virus problem, but the experiments could not be carried over to the conclusive period, due to severe decline, rendering the experimental population unfit for statistical interprettation. The decline was probably due to secondary infection. The lemons too exhibited decline, reducing the span of utility to hardly ten years. In case of mandarins, the leading commercial types of the country were assembled at Kallar Fruit Station and even these after 10 years of orchard life exhibited symptoms of distress and proved uneconomical. The mandarins in Tamil Nadu never exhibited profoundly the attractive colour as seen in Nagpur Santras, probably due to high humidity enjoyed in the sub-tropical belt of this state. The summer crop was invariably more sweet than winter since excess heat produces high sugar content. The grapefruits were found to stay comparatively better but is yet to catch the consumers preferance inspite of adequate publicity for nearly three decades.

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With the advent of Second Five Year Plan, a more dynamic and a diversified pattern of development was envisaged to include research on such crops as were of importance in the national economy either as a foreign exchange earner or as a produce in which the state was chronically deficit. Along with this was launched the first serious effort to carry the fruits of research to the farmers through a programme aimed at developing new orchards and in rehabilitating the old, declining ones. This programme much enlarged, was carried forward during the Third Plan Period and a foundation for an organised development not only to meet the internal needs but also in terms of export - import trade has now been laid. The serious bottleneck that posed in the tempo of work connected with the establishment of new orchards, met with atleast in Tamil Nadu, was the lack of supply of good plant material. The pedigree plant is the foundation of the orchard structure and is the primary factor which determines the success or failure. Orcharding is a long term profession and one cannot afford to take risk in choosing plants. No nursery-man can fulfill his legitimate function, if he fails to keep himself abreast with the increasingly available scientific and practical information. In the country there are many private fruit nurseries and a few states have already launched schemes for licensing and regulation of private fruit nursery trade. But in many states, this is yet to be done and private nurseries have, therefore, a free hand to play upon the gullible public, if they so choose. The problem of finding adequate source of supply of reliable plant material to meet the demand under the fruit development schemes has forced adoption of practices like temporary and tentative recognition to a few private nurseries after some inspection in this state. The unpractibility of dependence on private sources without adequate safeguards of inspection and certification was felt in Madras State as early as 1949 and steps were taken to establish Model orchards cum Nurseries, which are to play the dual role of Ocular demonstration centres of improved varieties and cultural practices and sources of supply of "pedigree " plant material of known parentage and proven performance. Uptodate 8 such centres have been established and there are proposals to have one for each district. It is to be mentioned here that this state was pioneer in establishing such Model Orchards which other states followed suit. The activities of these centres, to achieve the desired objectives, have been so planned not only to impart the technical know-how to the fruit growers but also to make the centres themselves as models in the matter of commercial orcharding on profitable lines.

b. Pathological Aspects:

"Citrus decline" is a general term covering a number of disorders, characterised by a number of symptoms like die-back of small branches, yellowing of leaves, poor

yields and ultimately slow death of the tree itself. Naik (1948) suggested that adverse soil conditions, particularly due to high water table and inadequate drainage, brought about early decline of citrus trees in South India. Marudarajan (1949) found that orange trees were suffering from mottle leaf and gradual deterioration in the plains of Madras State and got corrected as a result of Zinc application. On the other hand, the mandarins suffering from mottling and gradual defoliation in the sub-montane Kukal and Shevroys did not respond to Zinc, manganese and iron, although spectrographic analysis of leaves showed deficiency of these elements. The soils indicated deficiency in phosphorus but there was no response to its application. Decline of citrus is a universal pehnomenon first reported in South Africa about 50 years ago and a little later in Argentina and Java. During forties above six million trees were killed in Brazil and "Tristeza" was the name given to this disease. In 1939, "quick decline" was reported in California and a little later stem-pitting of grapefruit was reported from Australia (Asana 1959). Simultaneously it gained importance in India also and now it poses a threat to citrus production in this country as well as abroad. It has been the subject of considerable research in all the citrus growing countries of the world and studies in the various parts of the world show that "Citrus decline" is not a simple single disease but a complex phenomenon caused by several factors like (i) unfavourable soil conditions (ii) Nutritional disorders (iii) improper cultural practices (iv) pests and pathogenic diseases (v) Incompatible stionic combinations (vi) Virus and (vii) Nematodes. This malady is also known as decline, die-back, frenching, chlorosis etc. Undoubtedly it is one of the great tragedies of citriculture and unless the remedial measures are promptly taken, there is the danger of citrus industry becoming slowly extinct. Some 26 virusus are catalogued in "Citrus Industry" by Batchelor and Webber (1948). Out of them, three are commonly associated with decline of citrus trees according to Dr. Ramakrishnan. They are (i) Tristeza (ii) Psorosis and (iii) Xyloporosis. The recent addition to thse is "Greening Virus" according to Miss Froser, an Australian who recently visited all the citrus growing areas of our country. The last mentioned appear to be quite notorious. According to S.P. Capoor and D.G. Rao, the greening virus along with Tristeza virus is responsible for severity of decline and the need to contain the greening disease by control of its vector <u>Diaphonina Citri</u> has been stressed. However there are two groups of viruses (i) those affecting only certain stionic combinations and (ii) those affecting action irrespective of the root-stock used. Tristeza and Kyloporosis belong to the first category, while Psorosis belong to the second. Miss Fraser is of the opinion that "Greening Virus" is the main cause of the citrus decline. Chadha and Awasthi (1966) briefly indicated the history of Tristeza (Quick decline) and detection of it in various countries by various workers. It was Fawcett and Wallace (1946) who established

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the virus nature of quick decline. However, failure of sweet orange, Tangerine and grapefruit on sour orange rootstock, was observed in 1899 in South Africa. Similar failure was observed in Java in 1928, in Argentina, Brazil and California in 1939; In Australia, Newzealand, Ceylon and Venezula in 1949, in Florida in 1952; in Italy and Israel in 1956. This has so much of international importance, creating some common problems in citriculture, though it is called by various names in different countries. In this disease, phloem sieve tubes necrosis occurs checking carbohydrate transport from top to root, resulting in starvation of roots and heaving bearing, which exhausts the tree. Affected th e o becomes open and get subjected to sunburn. Die-back starts from the top and within two or three years, the trees become devoid of foliage.

The work done in India, commences with observation of Tristeza by Vasudeva and Cooper (1958) and confirmed by Nagpal (1959). Virus indexing experiments were carried on at Indian Agricultural Research Institute, New Delhi, Abohor, Saharanpur, Poona, Agricultural College and Research Institute, Coimbatore. Though accurate date is not available, it is doubtless that every year increasingly large number of trees are eighter drying or rendered commercially unprofitable. In Northern India the rootstock Kharna Khatta for various citrus fruits appears to be better than Jamberi, whereas the rough lemon and mandarin is causing quick decline of scions. This virus is transmitted by three aphids viz. Toxoptera sp., Aphis gossypii, and Myzus persicae.

In this country, the insect vector of transmission is reported to be Toxoptera citricidus. Aiyappa (1959) indicated that rough lemon is resistant to Tristeza but susceptible to Brown rot, Trifoliate orange is resistant to Tristeza but susceptible exocortis. Sour Orange is resistant to Xyloporosis but not to Tristeza. Virus diseases cannot be cured but their spread can be checked by disease free propagation material and control of insect vectors of transmission Nucellar embryony can be taken advantage of as the viruses are not seed transmitted. Adopting this strategy at Regional Fruit Research Station, Periyakulam, the pre-bearing period in citrus gave high hopes but even these succumbed later due to decline, probably due to secondary infection, in the absence of fool-proof protection from such infection.

Citrus Canker caused by Xanthomonas citri, characterised by brown corky outgrowths on leaves, twigs and fruits, commonly met with in Kagzilime. In extreme cases, defoliation occurs and the fruits fetch a less market value. The earliest record of the disease is reported in 1831 at Dehradun. Millions of trees were reported to have been destroyed and burnt in U.S.A., South Africa and Australia to completely erradicate the disease. The canker is observed in severe form on acidlime (c.aurantifolia), to a lesser extent on lemons (c.limon) and little or no infection on sweet orange (c.Sinensis) according to the studies undertaken by Dr. G. Rangaswami in Tamil Nadu. Sathgudi plants on Jamberi rootstocks were found to be relatively more resistant to disease.

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C. NEMATODE ASPECT:

Work done in several countries indicate that nematodes play an important role in causing the decline of citrus trees. The important are (i) citrus root nematode, Tylenchulus semipenetrans, (ii) burrowing nematode Radopholus similis, (iii) root lesion nematode Pratylenchus Sp and (iv) dagger nematode Xiphonema americanum. Certain other nematodes, though associated with citrus roots, their role is not yet known. The root nematode, Tylenchulus semipenetrans was found to cause slow decline in U.S.A., Spain, Palestine, Australia and South Africa. Studies indicate that none of the most important species are resistant to it. Burrowing nematode is reported to be restricted to tropical and sub tropical regions. The work in Florida (U.S.A.) shows that none of the known citrus species are unmune to it but some varieties and species are found to be better in their tolerance to this pest. Fazullah Khan (1955) reports of the decline of Wyanad mandarine due to the above pest. The type of damages nematodes do is by injuring bark of root, feeding on plant nutrients, unpairing the root growth and root function and possibly releasing toxic materials into the trees. They may also cause certain micro nutrient deficiencies. The detailed study of these parasites and appropriate methods for their eradication shall have to be undertaken. In more advanced countries soil nematicides are being used. To combat this malady, a nematology division was formed at Agricultural College and Research Institute, Coimbatore. The work done in India on this aspect is negligible.

D. PROCESSING INDUSTRY:

A processing unit was established at the Biochemical laboratory attached to Fruit Research Station, Kodur to undertake preliminary investigations on processing of available fruits including citrus under the able guidance and pioneering effort of Dr. G.Siddappa. This lead to the establishment of several commercial units in the State. With the partition of the state, Tamil Nadu was deprived of this unit. A laboratory unit has now been established at Agricultural College and Research Institute, Coimbatore with the advent of Post Graduate Institute to cater to the educational requirements. Two other units on commercial scale on Government Sector are now functioning at North Arcot District and Dharmapuri districts of this state. Some of the introduced fruits in citrus like Tahiti lime (a large fruited, seedless lemon with prolific bearing habit) and Malta lemons in the plains and Seville lemons in the hills have been established and these could foster a good trade in citrus fruit juices, marmalades etc. There are nearly 117 fruit preservation units in this state but most of them are at best only small scale units catering mostly to seasonal trade. A great scope exists for promoting a successful trade within the country and abroad, through the establishment of large scale fruit preservation units.

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III. FUTURE WORK:

No single horticulturist has devoted his entire attention to this crop, "citrus", solely, and establishment of research centres or projects entirely for this is of recent origin. The citrus decline is not confined only to this sub-continent but also in the entire world. During the international Symposium on Tropical Fruits conducted at New Delhi in 1958, leading citri-culturists of different nations significantly enumerated the ranges caused by citrus decline. When judged on broader aspects, the causes are common. As such, the need for establishment of a research project solely for citrus for South East Asia in a suitable centre with the active participation of the countries connected with the crop similar to the research project established for Rice in Phillipines and the project for vegetables at Taiwan. Monumental work has been done in Asia and the problem faced being common, should be tackled by co-operation and coordination of the countries in South East Asia. The issue must be mooted without any delay by Govt. of India.

ii. The National Horticultural Research Institute at Hassrgatta may establish a seperate project under the name "Citrus Project", entirely devoted to the problem facing the industry, with a chain of sub-centres in different states, each tackling the variety and kind of regional commercial importance. The existing centres, if found suitable, may be roped in. Since the issue is of national importance, the finance must be borne entirely by the centre. For positive results, eminent workers in the respective fields, irrespective of their age, must be pooled as a team to tackle this gigantic problem.

iii. Disease aspects should be studied in greater detail by undertaking isolation and study of various pathogens associated with citrus decline.

iv. Virus indexing to locate virus tree progany tree for use as propagational material shall be undertaken.

v. Production of nucellar lines of important citrus varieties.

vi. Standardisation of rootstock with high degree of compatability, suitable for different regions for all commercial varieties of citrus fruits is needed.

vii. Selection of rootstock for the resistance of root diseases, a high tolerance towards nematodes, salts, water logging and resistance for viruses shall be attempted.

viii. Destruction and elimination of all diseased trees of citrus, which pose a potent threat for further spread.

ix. Enforcement of strict quarantine measures not only for import from abroad but also for movement within the country.

x. The problems and programmes of research, development and increased production of horticultural crops including citrus are so distinct from those of agricultural crops that the agencies and organisations dealing with these crops in the state require to be brought under a seperate organisation through the setting up of "Horticultural Directorate" Other states have taken the lead over Tamil Nadu in this and the recent Southern Conference of All India Horticulatural Workers in Bangalore has stressed upon setting up of a seperate Directorate for horticulture. The states which have not fallen in line are to be recommended duly.

xi. By application of modern technology and scientific cultural practices, the major exporting countries of the world have been able to achieve high field yields. For instance the field yield of oranges (Washington Novel) obtained in Spain is 30 tons and in Italy 17 tons as against 10 tons (Mosambique) per hectare in India. It is necessary to launch upon a vigorous drive for raising the general level of field yields to withstand competition from worlds leading suppliers.

xii. Land holdings should be of a minimum economic size to facilitate application of modern techniques of cultivation. For instance, pineapple canners of Malayasia are statutorily required to own a minimum plantation of 1500 acres, while pineapple packers in Taiwan are required to ensure that at least 30% of the total requirements of fresh fruit are met from own plantations. Citrus orchards should be exempted from land ceiling act which is an important pre-requisite for building up a modern citrus industry in the country.

xiii. Bruce boxes are extensively used in exports of oranges, Tangerines, Clementines and grapefruit. The idea of conventional wooden boxes will have to be discarded as far as export market is concerned. Well equipped packing houses should be set up in centres of production and adequate supplies of packing materials are ensured.

xiv. Refrigerated trucks and air cooled railway wagons are extensively deployed in major supplying countries both for internal movement of produce and for export. These are necessities to prevent the damage in transport which is roughly estimated at 30% at present.

xv. Adequate provision of warehousing and cold storage facilities at packing houses, assembling points, rail and road heads, loading and unloading ports are to be ensured.

xvi. Enactment of legislation to control and regulate the private nursery trade is essential.

IV. SUMMARY AND CONCLUSION:

Tamil Nadu was one of the states which initiated early research work on citrus with the fond hope of establishing a remunerative citrus industry. The leading commercial variety, Sathgudi orange, (C. Sinnensis) owing its origin in Tamil Nadu, found its adapted home in a few southern states, contributing its due share in the economy of these states. The indigenous Kagzi lime was a remunerative crop in the southern region. The flourishing industry was badly ravaged with the onslaught of "Quick Decline" and this malady was found to occur with the same intensity in all citrus growing regions of the world. This decline was not due to single factor but found to be very complex involving virus, fungus, nematodes and a host of other agro-factors. The problem of citrus decline in India and abroad with particular reference in Tamilnadu is considered in its broad perspective with reference to unfavourable soil, nutritional disorders, unproper cultural practices, pests and fungal diseases, rootstock, virus and nematode aspects with general suggestions for further work. Work done in India and abroad on this problem is also indicated. A suggestion has been mooted to establish a seperate project in South East Asia in a suitable country similar to the rice research project in Phillipines and the vegetables Research Project at Taiwan established recently. Because of national importance a separate project on similar lines is to be formed in the National Horticultural Research Institute at Hasargatta with a chain of sub-centres to tackle problems of regional importance and the project is to be governed by a team of eminent workers in the field, irrespective of age, in order to utilise the rich experience of the available workers. The complex nature of citrus decline has been enumerated with general suggestions for further work. The present status places the citrus industry at cross-roads, with inability to arrest the decline or even suggest temporary ameliorative measures. The development programme is at stand still. If the present deteriorating conditions are allowed to continue, the citrus industry will loose its identity very soon and perhaps find a place, as a museum specimen in a botanical collection as an horticultural curiosity.

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Item No. 2

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CURRENT SITUATION REGARDING CITRUS VARIETIES AND ROOTSTOCKS

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Citrus Die-Back Scheme
GONICOPPAL : COORG

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The citrus decline or 'citrus die-back' problem of the country has been attributed to many factors by several workers. Unfavourable climatic and soil conditions, mismanagement and improper cultural operations, defective planting material and malpractices in the nurseries have been reported to predispose the orchards to the decline. Malnutrition (both micro and macro nutrients), stonic incompatibility or disorders, pests including nematode, and diseases of fungal and viral nature have also been assigned to the malady. Therefore the " Citrus die-back of India" is a disease syndrome of multiple factors. The decline due to neglect, mismanagement or due to attack of insect pests can be corrected by adopting timely orchard management practices and plant protection measures; but the malady assumes an alarming situation if the factors like soil fungi, nematodes, salinity and micro-nutrient deficiency, entangled with one another, form a complex. On various individual problems or factors involved in the decline, considerable research is being carried out in all the citrus growing countries of the world. In India, the decline problem has become more complex due to the involvement of more than one virus such as tristeza, greening etc., associated with other factors like fungal root rots or nutrient deficiencies which have been already reported in the country.

In this paper, the role of rootstocks in combating the malady or their involvement in causing the decline have been presented. Different root-stock varieties possess different characteristics and their influences vary according to the scion

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varieties, soil conditions environmental factors etc. A rootstock which can exert vigour, may show dwarfing influence on another scion variety. A rootstock which can induce resistance against a disease, can make another variety more susceptible to the same disease. Therefore, it is essential to know how far the role of rootstocks are important in the decline and how best they can be adopted as a solution to the problem facing the citrus industry of the country.

In earlier periods, the failure of stock-scion combinations was generally attributed to incompatibility due to physiological rejection. But, of late, on account of the involvement of viruses the success or failure of stionic combinations are being attributed to their degree of resistance or susceptibility to virus and other diseases.

Rootstocks-vigour and virus aspects

Earlier work in the former Punjab, at Peshwar, Brown (27) reported that Rough lemon induced more vigour to Malta, while Sour orange and Citron the least. Sweet lime was found medium vigorous for Malta but most vigorous for Sangtra. Growth of Sangtra on Rough lemon and Citron was unsatisfactory while on Sour orange fairly satisfactory. Lal Singh and Sham Singh (60,61) Bajwa and Singh (14) and Singh and Nagpal (92) reported that, at Montgomery in the trials laid out for the scion varieties Malta, Santra and Grapefruit, among the rootstocks (Sweet lime, Rough lemon, Citron, Karna Khatta, Shaddock and Nasnaran), Karna Khatta was found most vigorous for Santra and Grape fruit, but showed delayed incompatibility for Malta. Citron and Sweet lime had dwarfing effect on malta and Grape fruit. Rootstock Nasnsran was found fairly satisfactory for all the three scions. Malta on Rough lemon was best. Rough lemon and Shaddock were found fairely satisfactory for Grape fruit. The initial performance of Valencia orange on Jambhari (a strain of Rough lemon) in West Punjab was most vigorous as reported by Khan (51). Other rootstocks, Kharna Khatta, Rough lemon, Sour orange and other three strains of rough lemon were fairly vigorous. Ahmed Saeed and Kripal Singh (5,94) while reviewing the same trial reported that

Jatti Khatti proved to be the best for the Malta blood red while Nasnaran proved best for Malta local and Sangtra. Karna Khatta was proved to be failure for Malta blood red. But Rough lemon as well Khatta were proved good for Valencia late. Lime, Sweet lime and Lemon (Galgal) proved unsatisfactory for both Sweet oranges and Sangtra. Bakshi and Dhillon (16) reported incompatibility of Rough lemon for Mosambi and Blood red with clear symptoms of bud-union crease. Nauriyal and Chauhan (73) have also reported incompatibility of the same scion varieties with Jatti Khatti stock which was once reported to be good. It is reported that in the same trial, scion varieties Jaffa and Valencia have not developed bud union crease on Rough lemon stock and their stionic compatibilities were satisfactory (17). The Rough lemon as a rootstock for Dancy, Honey, and Wilking mandarins have been reported to be promising (37). Nijjar (75) has reported that Rough lemon stock is susceptible to nematodes and hence its future performance need be watched in the Punjab. Bajwa and Nagpal (45) attempted for a comparative study of vegetatively propagated stocks and apogamic seedlings stocks in respect to vigour, cropping of Marsh seedless grape fruit scion and reported that vegetatively propagated rootstocks induced higher yields and greater vigour than the apogamic seedling stocks. Among the rootstocks, Kharna Khatta and Lemon were good and rootstocks Sweet lime and Citron, less satisfactory for Marsh seedless. Singh (96) has reported that the Nasnaran is a promising rootstock for Santra and Malta in Punjab. Ahmed and Rashid (6) reported that Seville Kimb is a good rootstock for Kinnow mandarin. Ahmed <u>et al</u> (7) have also given a resume of citrus rootstock investigations in the former Punjab. Khan and Haqe (53) discribed the ten rootstock varieties of the Punjab. Khan and Khan (52) reported scionic influence of Valencia late on rootstocks Kharna Khatta, Jullandar Khatti and Rough Lemon.

In Madras, at Kodur (now in Andhra Pradesh) Naik (74), Rangacharlu <u>et al</u> (82), Challappa <u>et al</u> (34) reported the results of rootstock investigation for Sathgudi orange. They found that among the rootstocks in the trial Sathgudi stock performed well in with-standing the tree decline malady, although it was less vigorous

and less precious in cropping, than Jambhiri, Lime, Gajanimma and Billikichilli. The Sour orange and Lime stocks were worst affected. The seedling trees of Sathgudi (control) were also found to have with-stood disease, despite the fact they were late to come to the bearing (83), (96). Lime budded on lime was superior to other stocks but the seedling lime tree was found far better. Rangacharlu (84) states that the stocks Jambhiri, Kichilli and Gajanimma which were once declared as promising stocks have been found to decline much faster than those on Sathgudi stock and suggested that the present extensively employed Jambhiri should necessarily be replaced by Sathgudi in order to save the citrus industry in the State. In earlier trial it was reported (1) that the Sathgudi on Feronia Limonia, although precocious in bearing, had severely dwarfed tree.

In Maharashtra, Cheema and Bhat (35) reported that inarching Santra and Mosambi oranges on Feronia and Aegle marmelos were not successful. In the regions of Madhya Pradesh and Maharashtra, the most commonly used rootstock is the Rough lemon (Jamburi or Jambhiri) (48). Shrivastava (106) opined that although the Sweet lime was the best stock in Bombay State, the Jamburi was generally used. Allan (13) reported that the Jambiri is a good rootstock for Mosambi and Grape fruit, while the Sweet limegood for Santra, and Karna stock, for the Malta. Phadnis (77,78) reports that in Nagpur, (Tharsa) rootstocks Rangpur lime, Jambhiri, Jatti Khatti and Sweet lime were performing well for Nagpur santra in respect to tree vigour and yield. The Sour orange proved the worst. At Srirampur, rootstocks-Rangpur lime, Jambheri (Bombay) Soh-myndong, Jambhiri (Kodur), Kharna Khatta were reported to be performing well for mosambi (4). Herale, Sour orange and Citron were worst. Nagpal (70) reported that the stionic failure of Sour orange stock for sweet oranges in Bombay State was due to Tristeza virus; while in the year 1970-71 observation the trials with rootstocks for Mosambi revealed that Rangpur lime, Jamberi (Bombay and Kodur), Sohmyndong and Billikichilli were found performing good with respect to vigour and yield. The next best were Mosambi and Adajamir. The rootstocks Herale (C. aurantium), Sour orange (C. aurantium), Bengal Citron and Atalancia were found unsuitable.

In Uttar Pradesh, Hayes (48) reported that Tristeza virus like symptoms were noticed in Sweet oranges budded on Sour orange rootstock, collected from N.W.F. province to Allahabad in 1934 and they showed much 'die-back' symptoms, while those on Karna stock remained healthy. And he opined that the tristeza virus present in India might be of a less virulent strain than those in some other countries. At Saharanpur, Singh (102) reports that rootstock Florida Rough lemon induced better vigour for mandarin varieties- Srinagar and Rangtra; and for Sweet orange varieties - Navelencia and Mosambi, than rootstock Karna Khatta. Later was better for both mandarin and Sweet orange varieties, studied than Florida rough. He also observed a significant response of both the rootstocks- Kharna Khatta and Florida rough to Nitrogen application in regard to fruit size and yield but not, in regard to vigour aspects. Singh(98), observed that the rootstock Citrus limon was better as a compatible stock for Mosambi, and C. maxima, for Khagzi lime C. Karna, P. trifoliata and others. Singh (97), reports that Sweet lime was best for Mosambi in respect to vigour, yield, fruit quality and resistance to collar rot; and Kharna Khatta was found second best. The Jambhiri and Florida rough were less satisfactory. The performance of Seville orange and Sylet lime were unsatisfactory. In 1962 it was observed that rootstocks Florida rough and Italian-76 were performing good for mandarin variety-Hill. For mandarin Srinagar, the rootstock Florida rough followed by Kharna Khatta, were good. Seville orange, Sweet lime followed by Kharna Khatta, were good. Seville orange, Sweet lime and Jambhiri were found unsatisfactory as rootstocks for both the mandarin varieties. Singh(99), reported that, for Sweet orange- Vanille, the rootstock Kharna Khatta was found more vigorous than Trifoliate rootstock.

According to Woodford (114), in Assam (Burnihat), in the rootstock trials, the rootstock Sohnydong (Rough lemon) was found best for Khasi mandarin. Panijamir (a strain of Sweet lemon) was initially promising but showed delayed incompatibility as a rootstock for Khasi mandarin. The stock Rabatenga (Pummolo type) was found good for Grape fruit. According to Das (38), the

rootstocks Karun jamir (Sour orange) and Rababtenga were found unsuitable for Khasi mandarin. The rootstocks Satkara (*Citrus macroptera*) and the Citron were found to have dwarfing influence on the scions. The Kata jamir (a rough lemon type) was reported to be promising in the earlier observations. Bhattacharya and Dutta (21) reported that in the observational trial, out of 11 rootstocks, Katajamir (*C. jambhiri*) was found satisfactory for the scions Khasi mandarin, Valencia late, and Musambi and had slight dwarfing effect on Washington Navel. Other rootstocks Birajora (*C. medica*), Patilimbu (*C. limon*), Soh-synteng (*C. limon*), Panijomir (*C. limon*), Soh myndong (*C. jambhiri*), Soh-sarkar (*C. karna*), Karunjamir (*C. aurantium*) , Adajumir (*C. assamensis*), Rababtenga (*C. grandis*) and Satkora (*C. macroptera*) were found unsatisfactory for all the scion varieties -- Khasimandarin, Mosambi Valencia late and Washington Navel.

In Orissa (2) it was reported that the rootstocks Jambhiri Sweet lime and Kharna Khatta were promising for Nagpur Santra.

In Mysore State, Coorg, in the trial layed out in 1955, the observation taken in the year 1970-71 have revealed that the rootstocks Belladakithuli, Rough lemon (Coorg strain) are more vigorous than others with respect to stock and scion girth, tree height and tree volume. Baduvapuli and Karna Khatta were less vigorous and seem to have dwarfing effect. The other rootstocks- Sour orange, Lime Naichakotha were found unsuitable and they exhibited severe chlorosis and twig die-back. The failure of these rootstocks can be attributed due to tristeza virus as evidenced by stem pitting, honey combing symptoms. In the stionic conginiality, more stock-over-growth than scion was seen in the rootstocks Balledakithuli, Baduvapuli (performing) Naichakotha and lime (failure). The stionic conginiality was good with lime, Naichakotha, Baduvapuli and Belladakithuli, although the former two rootstocks were failures. Also, fairly less incongniniality was noticed in the rootstocks Rough lemon, Khatta and Sour orange, in which case the former two rootstocks are still performing good while the later one has declined. The decline of rootstocks is found to be irrespective of the degree

of stionic conginiality. With respect to yield also, the rootstocks, Belladakithuli, Baduvapuli, Rough lemon and Khatta have performed well. The performance of seedling mandarin (Control) in all respects is satisfactory but the percentage of tree survival is low, due to root rot infections. With respect to fruit quality the Coorg mandarin on Sour orange and Lime recorded low T.S.S./Acid ratio, high acid content in fruit juice (3).

In the rootstock trial layed out in the year 1956, the observation recorded during the year 1970-71 showed that the rootstocks Rough lemon (tree rough) and Kodakithuli are more vigorous than others. The other stocks Lemon, Lime Sadhaphal, Molepuli, Pummello and Grape fruit are failures, since they recorded poor growth, more percentage of chlorosis and severe tree decline condition. With respect to stionic conginiality, Rough lemon recorded slightly scion-over-growth while Kodakithuli slightly stock over growth, but the stionic congeniality is good in both the stocks. The vigour performance of seedling mandarin (Control) is satisfactory with respect to tree height, volume, and also stem girth. With respect to bearing, the rootstock Kodakithuli and Rough lemon recorded maximum yield while seedling mandarin (Control) fairly good. With respect to T.S.S./Acid, Rough lemon showed higher value than other rootstocks and is par with the seedling (3).

In the 1961 layout, the observations taken during 1970-71 showed that the rootstocks Cleopatra mandarin, Troyer citrange, Rubidoux trifoliate, Australian trifoliate and Pomeroy trifoliate recorded fairly good tree volume and and less percentage of chlorosis. Tree height was more in Cleopatra mandarin. The stionic conginiality was good in all the rootstocks although the West India lime and Mexican Key lime are poor in growth, and showed more decline proving their failures. The vigour performance of Kara and Kinnow mandarin as rootstocks do not seem to be promising for Coorg mandarin. With respect to bearing, Cleopatra mandarin, Troyer citrange and all the trifoliate strains recorded good yield. No marked difference was noticed in fruit quality aspects among the rootstocks and

possible cause was found out by Fawcett and Wallace (39) as due to virus and its virus nature was proved by Bitancourt in the year 1944. This virus was called Tristeza in South America and quick decline in California. Grant et al (47) conducted extensive screening trials with different varieties in Brazil. He found that 19 varieties of Sour and Bitter Sweet oranges 10 Grape fruit and 19 Pummelos, Shaddocks and their hybrids tested were non-tolerant. Other non-tolerant varieties were 10 tangelos, 18 lemons, 3 limes, one Citremon, one Nippon Kemquant, citrus macroptra and 2 strains of severinia. Tolerant varieties included 12 sweet orange varieties, 26 mandarin varieties 16 tangelos, one trifoliate orange, 6 Citranges, 6 citrumelos and 2 Sweet lemon varieties. Among rough lemon varieties, some seemed to be tolerant while other non-tolerant. According to them Sweet oranges and mandarins can be safely grown on tolerant rootstocks, while Grape fruit and limes might decline on tolerant roots. In South Africa, Oberholzer (as cited by Hayes 1953) reported that healthy trees can be grown when buds are taken from nucellar trees in infected areas, but non-tolerant root-stocks should not be used. Provan (80) reports that in Australia most of the Sweet orange varieties do well on the Rough lemon except Malta Blood which was a failure on this stock. Batchelor and Webber (18) opined that Sweet stock might hold good promise as successful rootstock in California. Marloth (65), Marloth and Basson (66) in South Africa report that Emperor mandarin is a good stock for Shomouti due to resistance to viruses, and Rough lemon is only next best. Lyon (62) in Australia reports that Rough lemon is good for Sweet orange, but not suitable for mandarin while virus resistant symons Sweet stock is good for both Sweet and mandarin oranges. Bitters (22) reports that Troyer citrange has failed for Eureka lemon in California. Later Wallace and Snow (110), Calavan et al (29) report that the failure of Troyer might be due to Tristeza virus of a severe strain. Knorr (58) Knorr and Collins(59) report that Rough lemon and Cleopatra declined the growth of Murcott orange in Florida due to virus. Calavan et al (29) report the failure of C. macrophylla for lemon due to Tristeza. Hodgson (49) reports

that in Japan, C. junos is commercially used for Satsuma, while in Israel, Sweet lime for Jaffa is popularly used. Morrell (68) in Brazil, Robert (89) in Indian River, reported that Rangpur lime Rough lemon, and Cleopatra are commercially used as rootstock because of their tolerance to Tristeza and drought. Platt (79) reports that C. macrophylla is tolerant to Boron toxicity and Phytophthora with better nutrient absorption but it is susceptible to Tristeza and nematodes. Russo (90) reports that C. volkameriana develops bud-union crease with Blood orange. According to Moriera and Salibe (67) in Brazil the stocks Sunki, Kinnow, Troyer, C. volkameriana, C. Karna and some trifoliates have been found to be tristeza tolerants. And trifoliate varieties like Christian, Rubidoux, English small, Severinia spp. and Fortunalla spp. have been reported to have dwarfying effect. Bitters et al (25) opined that the Genera Citropsis, Atalaneia, Clymania, Swinglea etc., may possess good prospects as rootstocks.

Rootstocks ------ Fungal Diseases:

Rootstock investigations have also been carried out elsewhere with reference to their susceptibility or resistance to soil-borne fungii. Rough lemon, Cleopatra, Troyer are reported to the susceptible to P. parasitica(28) From inoculation tests, it has been revealed that Yuma and Carrizo citranges, some trifoliates (45); also Troyer, Natsudaidai, Citrimon 1449 and Ichang lemon (55) ; C. macrophylla and C. taiwanica (23); and C. volkameriana (33) are resistant to Phytophthora root rots. Koltz et al (55) in the further trials, found that the Trifoliate selections Texas, Barnes and U.S.D.A. are the most tolerant stocks against P. citrophthora and parasitica. In another trial C. amblicarpa, Trifoliate selections Argentina, New Mexican, English, Ichang Pummelo and Rangpur lime are found most tolerant. According to Cppor and Bakshi (31) Rough lemon (Indian) is fairly resistant to foot rot. Klotz et al (56) in their field inoculation trial observed that even the resistant trifoliate varieties become affected by foot rot through the incisions or cuts on the cambium surface. They concluded that

the degree of susceptibility/resistance of the stocks is related to the amount of chemical substances like glucosides, tanins, gallic acids etc., in the outer bark. In another trial, trifoliate selections- Texas, Japanese Tetraploid, Davis-B, English and Rubidoux were found most resistant to foot rot diseases.

In India, not much work on these aspects seems to have been done.

Rootstocks-Nematodes, Salinity and Nutrient uptake

Some studies in relation to nematode resistance and salinity tolerance have also been conducted. Strauss (107) reports that Redge pineapple, Milam and Eastes are nematode resistant. Van Gundy and Kirkpatrick (109), Bains et al (20), reported that Trifoliate varieties Severinia, and hybrids of Rough lemon plus trifoliate, Kusaie lime plus Trifoliate hybrids are resistant to Tylenchulus semipenetrans while Cleopatra mandarin not resistant and Troyerless resistant. Perrotta and Catara (76) report that Rangpur lime and Cleopatra mandarin are susceptible to citrus nematode while Troyer and C. volkameriana resistant.

In the replanting trial, Troyer citrange and trifoliates (19), Concordia trifoliate and Cleopatra mandarin (42) have shown good performance, while Sweet orange, Rangpur lime and Rough lemon, failed.

With regard to tolerance to toxicity of salts Cooper (37) reports that Sweet lime, Rough lemon, Citranges, Rangpur lime, and Cleopatra mandarin are tolerant to toxicity of salts upto 1800 ppm. while Severinia Buxifolia is resistant to boron excess and toxicity of salts upto 4000 ppm Trifoliates have shown least tolerance. According to Muntgomery (69) and Ford (40,51), Sweet orange and Emperor mandarin stocks are saline soil resistant, while Rough lemon not resistant.

Nutrient uptake of rootstocks have also been studied. Wier (113) and Maliphant (64) report that Rough lemon is a good absorber of K, Mn: Rangpur lime, good absorber of N, K, Mn and

Zn; Cleopatra mandarin for N, Mg, Ca, Mn and fairly Zn; and Troyer and Trifoliates for N, Ca, Mg and Fe. At Srirampur (1970-71) studies on nutrient-uptake by rootstocks have been initiated. It is observed that Rangpur lime, Jambiri and Sohmyndong are good absorbers of N P_2O_5 and K_2O (3)

Not much work seems to have been done in India on these aspects.

PRESENT SITUATION AND SUGGESTIONS

From the appraisal of the rootstock studies conducted in the country it is seen that although quite voluminous amount of work has been conducted with different scion varieties, but their results are fragmentary. No single rootstock can be pin-pointed to be the best for all scion varieties, soil conditions, disease resistance, specially considering the involvement of viruses. In view of the fact that viruses like Tristeza, Greening etc., root rots are very important in the problem of citrus decline, work on coordinated basis is needed in different parts of the country. Virus-fungal complex and rootstocks need special attention in future investigations on different citrus scions.

However, from the present knowledge of the results of the rootstock investigations, it is suggested that the performing rootstocks Rangpur lime, Poncirus trifoliata, Cleopatra mandarin, Kodakithuli and Rough lemon can be used until best rootstocks for commercial scion varieties are evolved. Rangpur lime for all soil types; Poncirus trifoliata in all types except in saline soils, Cleopatra mandarin and Kodakithuli for medium clay loam to sandy loam soils; and Rough lemon for light soils (with caustion, not to use for Malta and Mosambi oranges) can be recommended.

Suggestions for future line of work:

1) Virus free scion mother trees must be selected and only virus free budwoods must be employed in the future rootstock trials (11)

2) A rigorous search should be carried out to find out the wild citrus species and varieties indigenous or exotic, and are screened for various aspects (104)

3) All the existing species and varieties in an germplasm collections must be subjected for screening tests to study their relative resistance against viruses, salinity, drought soil fungii, nematode (11).

4) To shorten the testing duration and to safeguard against failures, the selection of rootstocks for their adaptation to different varieties might be hastened by correlating such properties with chemical constituents or physiological functions (32), (91).

5) Only the tested or screened rootstock varieties should be employed in the regular field trials for certain specific scion varieties on a long range basis. All the strains of Rough lemons, Rangpur limes, Sour oranges should be tested.

6) Hybridization work should be taken up to evolve certain hybrids using Poncirus trifoliata, Sour orange, Rough lemon, Rangpur lime, Sweet lime, Cleopatra mandarin etc., and screening the hybrids for their resistance to various adverse factors.

7) Inter specific or inter generic crosses can be made using distant citrus relatives such as Citropsis, Atalantia Severinea, Murraya, Feronia Poncirus etc., and their hybridsto be screened (25), (32)

8) Breding work to evolve nucellar lines need be emphasised for future use in rootstock trials (11).

9) Replanting studies may be initiated in declined orchards with already proven rootstocks.

10) Rootstock studies in respect of root-system, irrigation, nutrition etc., need be taken up(11).

11) Interstock technique in rootstock trials may be tried (72)

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ABSTRACT

The citrus decline problem in the country cannot be attributed to a single factor or a casual organism. The malady is a complex of different adverse or limiting factors of primary as well as secondary nature. Also it is known that causal factors particularly imbalanced nutrition, defective orchard practices, stionic in-compatibility, viruses, fungal diseases, nematodes, infected plant material etc. are involved in the disease syndrome of die-back.

In this paper the role of rootstocks, their merits and demerits, their involvement in the decline problem and their future utility in combating the malady have been discussed. From the present knowledge gathered from the investigations conducted the suggestions for future line of work have been included on aspects like screening the citrus varieties for various resistance aspects, evolving better varieties by inter-specific and intergeneric hybridization etc.

Item No 3

RECENT ADVANCES IN CITRUS NUTRITION

(P.N. Takkar, N.S. Randhawa, J.S. Kanwar and J.R. Bhambota)

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The results of research on citrus decline in India reveal that it is a complex problem caused by several factors like nutritional disorders, poor physical condition of soil, salinity and alklinity in the soil, presence of hard pan in the root zone of the plants, defective drainage and high water table, pest and diseases, nematodes and viruses.

In this paper on attempt has been made to analyse the problem of citrus failure in India due to nutritional disorders and to highlight the gaps in the existing knowledge.

1. INTEGRATED SOIL AND LEAF ANALYSIS OF CITRUS BELT OF INDIA FOR PREDICTING RESPONSES TO CITRUS.

Very little attention has been paid to the relationship between soil and citrus nutrition by taking an integrated view of the soil properties and nutritional status of citrus trees. Foliar analysis or soil analysis alone have been done but the contribution of various factors to manourished and diseased condition has not been identified in carefully planned experiments.

Ramamurthy and Desai (1946) found the excess of iron to be the cause of citrus die back. Mukerjee (1949) observed that diseased leaves of citrus from Coorg and Madras had low zinc and manganese content and in case of Coorg low copper also. The soils from these tracts also contained low quantity of Zn, Mn and Cu in addition to poor status of total nitrogen and available potassium. Mariakulandai and Durairaj (1958) pointed out that the cause for citrus decline in Madras and Coorg was mainly nutritional. Choudhary (1954) reported deficiency of boron, zinc and iron in Assam's sour oranges, mandarins and valencia, respectively.

Singh and Singh (1953) attributed citrus die back in Uttar Pradesh to copper deficiency but later on Singh and Aggarwal (1961) reported beneficial effects from zinc sprays only. Kumar and Sharma (1960) attributed chlorosis in citrus in Madhya Pradesh due to deficiencies of copper, zinc and iron.

In Punjab, Kanwar and Randhawa (1960), Kanwar et al. (1963) and Nijjer and Singh (1971) reported higher contents of nitrogen, calcium, Magnesium and zinc and lower contents of .... /2-

phosphorus and potassium in healthy leaves (Table I)

Table I: Composition of healthy and chlorotic citrus leaves:

Condition of leaves	Percent (Oven dry basis) N	P	K	Ca	Mg	Ppm (over dry basis) Cu	Fe	Mn	Zn
Healthy	2.7	0.22	2.0	3.2	0.39	20	148	28	17
Chlorotic	2.5	0.32	3.1	2.6	0.35	18	146	33	11

Randhawa et al. (1967) made analysis of soil, sub-soil and plant to study the role of nutrients in citrus decline in Punjab. Their study revealed that even though available phosphorous and potassium in majority of citrus growing soils were in the low to medium range but their amounts in the leaf samples were in the high to excess range as is evident from the data in Tables 2 and 3. This showed that when there was an apparent or latent deficiency of any essential nutrient, the plants have a tendency to accumulate both phosphorus and potassi Thus the question arises whether P and K concentration is the ca or effect of unhealthy condition of citrus cannot be resolved from these data and it can only be inferred that zinc and manganese deficiency and possible iron deficiency was the cause of unhealt condition of citrus (Tables 2 and 3).

TABLE 2: Chemical analysis of surface and sub-surface soils from citrus orchards in Punjab.

Soil	Ph 1:2(Soil water)	E.C. mmhos/cm(range)	$CaCO_3$ (%)	O.C. (%)	Available nutrients kg/ha N	P	K	ppm Mn	Fe	Zn
Surface 0-24"	7.7	0.10 to 0.44	0.90	0.20	79	6.6	154	5.2	58	
Sub-Surface 24"-72"	7.8	0.10 to 0.32	3.10	0.14	65	5.4	118	2.7	11	

.....3/-

Table : 3 Composition of healthy and chlorotic orange leaves (expressed on dry matter basis)

Condition of the leaves	Percent N	P	K	Ca	ppm Cu	Fe	Mn	Zn
Healthy	2.49	0.18	1.65	3.25	8.2	158	30.3	16.3
Chlorotic	1.96	0.24	2.14	2.38	7.9	122	23.0	11.5

Shome and Charan Singh (1965) found that Ca, Mg and K were present in citrus leaves in connentrations greater than the deficiency limits. They observed that irrespective of healthy or diseased conditions of plant Ca + Mg was negatively correlated with K.

Nair et al. (1968) found that in the leaves collected from the 'unhealthy' plants from New Delhi, Abohar (Punjab) and Sri Ganganagar (Rajasthan) there was significant reduction of zinc but not in other elements such as Cu, Mn and Fe, indicating that these leaves were deficient in zinc alone as compared to the leaves from healthy plants (cf. Table 4). They also observed that the soils bearing unhealthy plants were low in available zinc and organic matter but high in available Mn, P_2O_5 and in certain cases even high in available Cu also.

Table 4: Nutrient status of 4-5 months old leaves from March Flush

Localities	Varieties	Condition of tree	Present nutrients (dry weight basis) N	P	K	Ca	Mg	Micronutrients in ppm (dry weight basis) Zn	Cu	Mn	Fe
Punjab	Pine-apple	Healthy	2.60	0.19	1.73	3.5	0.44	10.9	25.8	31.5	240
Rajasthan	Blood-red Mosambi, Malta										
New Delhi	Common Jaffa Lahore Local Nagpuri	Un-healthy	2.37	0.26	2.01	2.06	0.36	9.1	28.6	30.0	202

Nauriyal et al. (1970) could not find any significant difference for zinc, copper iron and manganese in chloratic and healthy leaves but observed that boron was present in very high concentrations both in healthy and unhealthy or trees and in some trees it went upto 518 ppm. without exhibiting any visual symptoms of boron toxicity.

TABLE : 5: Micronutrient status of leaves of healthy and declining citrus trees (Nauriyal et al 1970)

Condition of tree	Mn	Fe	B	Cu	Mo	Zn
			ppm			
Health*	36	194	362	20	0.89	26
Declining *	38	194	334	13	1.01	25
Healthy **	45	252	292	14	1.04	24
Declining **	39	208	283	17	0.76	24

*Values for Blood-red varieties only

** Values for Jaffa, Valencia late and Mosambi varieties

Randhawa (1970) reported that available boron in these soils ranges between deficient and normal and they attributed the presence of excess boron in leaves to preferential absorption of boron by rough lemon root stock of the citrus plants. Perusal of the above literature reveals that available boron in citurs orchard soils in Punjab is in the normal range.

It is felt that there is a need to undertake research studies on the following lines.

Most of the above research studies have been made on citurs plants either that were affected by virus (Rajan, 1972), nematodes and insects (Bindra, 197 Since such factors effect the nutrient absorption and utilization by plants and the interpretations from such data could be erroneous or unrealistic. It is, therefore, highly desirable that in future the nutritional studies must be conducted on plants that are free from such hazards. There is also a need in developing leaf analysis standard best suited for soil and climate association of important citrus growing regions of India

It is very essential that intensive research on citrus nutrition by a team of scientists consisting of soil scientists and Horticulturists should be taken up. Soil, sub soil and plant tissue need to be examined for the nutrient status and their interrelationship be studied. There is sufficient evidence in India and abroad that zinc and boron status of citrus is very much influenced by rootstock. Thus there is an urgent need of the study of stock scion relationship.

II . RESPONSES TO DIFFERENT METHODS OF NUTRIENT APPLICATION

(a) Effect of foliar application of micronutrients on affected citrus plant.

Cheema and Bhat (1928) reported beneficial effect of zinc application to citrus plant. Aiyappa et. al (1959) and Mani et al. (1959) observed that spraying of zinc sulphate did not give full recovery at all times and required repeated sprays.

Kanwar and Dhingra (1961 & 1962) and Bhambota et al. (1962) obtained significant recovery from chlorosis, increase in leaf area, number of fruits per trees, weight, circumference and volume of each fruit with sprays of zinc and zinc plus iron solutions.

Som Dut (1962), Prithipal Singh (1963) and Som Dutt and Bhambota (1967) found 1.0 per cent $ZnSO_4$ sprays to be the best remedy for chlorosis in citrus (Table 6). They also observed a decrease in N content and increase in P, K and chlorophyll contents in citrus leaves with sprays of zinc, iron and copper.

TABLE 6: Effect of different connentration of zinc sprays on the incidence of chlorosis (Som Dutt and Bhambotta 1967).

Concentration of $ZnSO_4$ (per cent)	Mean increase in percentage chlorosis			Mean Chlorophyll (a+b) in Mg/100g of fresh green leaves
	Nov. 1960 (1st spray)	March 1961 (2nd spray)	March 1962 (4th spray)	
1.00	25. 7	3.5	0.8	240
0.80	33.7	14.0	4.4	192
0.6	37.8	18.5	8.0	167
0.4	43.7	22.3	20.3	149
Control	44.9	29.1	41.7	106
C.D at 1%	10.4	17.7	12.7	67

Dhingra et al. (1966) observed 69, 55 and 52 per cent reduction in chlorosis with foliar application of 0.3, 0.6 and 0.9 per cent $ZnSO_4$ solutions respectively. They noticed 0.3 per cent solution as affective as 0.6 and 0.9 per cent $ZnSO_4$ solutions.

Studies o n correction of multiple deficiencies (Sandhu et al. 1968) showed that foliar application of 0.4 per cent $ZnSO_4$ solution alone and in combination with iron even once a year resulted in a significant reduction in chlorosis and increased zinc and iron connentration in the leaves (Table 7).

Table 7: Effect of zinc and iron application on Chlorosis and leaf composition:

Treatment	Average reduction in chlorosis (%) (1966 and 1967)	Average mineral composition of leaves on oven dry basis 1966 and 1967.	
		Zn (ppm)	Fe (ppm)
1. Control	30.6	16.5	147
2. $ZnSO_4 - 7H_2O$	76.9	28.9	177
3. $FeSO_4-7H_2O$	52.3	18.1	247
4. $ZnSO_4 + FeSO_4$ at one week interval	64.4	17.4	200
5. $ZnSO_4 + FeSO_4$ at three weeks interval	68.0	21.0	237

Foliar application of zinc alone, followed by its combination with iron at one week intervals proved more effective treatment. An immediate combination of zinc and iron and to less extent their application at three week intervals showed some antagonistic effect, as indicated by the incidence of chlorosis and their accumulation in leaves (Table 7).

Manchanda (1970) observed that application of zinc, zinc + manganese, zinc + iron and zinc + copper increased the percentage of healthy trees and considerably decreased those showing minor, medium and acute chlorosis. The improvement brought by these treatments was of the order of zinc + copper 7 zinc + manganese 7 Zinc + iron 7. He also found an increase of 227-273 350-400, 69-71 and 48-95 per cent increase of zinc, copper, manganese and iron, in the leaves sprayed with the respective micronutrient over the control.

In Uttar Pradesh, Singh (1953) observed iron deficiency in citrus plants that responded to iron injections. In Madras, Marudarajan (1949), reported benefi effect of zinc application. Mukerjee (1949) reported that foliar spray of zinc and with different micronutrients reduced the incidence of citrus chlorosis in Coorg. Chlorosi in citrus was cured by zinc sulphate spray (Singh and Singh, 1953; Dikshit, 1958; 1959; Aiyappa and Subramanian, 1959, Aiyappa et al. 1969; Mani et al. 1959, Singh and Agarwal, 1961). They observed either partial or complete recovery. Diskshit (1961) recorded a higher recovery with Zn + N and found that chlorotic leaves contain low amount of nitrogen. For better utilization of zinc, the presence of sufficient nitrogen is required. Aiyappa et al. (1967) observed beneficial effect of Zn and Cu sprays separately and in combination, in reducing the chlorosis. They also found that yield of fruits was significantly increased by spray on Zn while non-significantly by Cu..

At I.A.R.I., New Delhi, Nair and Mukerjee (1970 a and 1970 b) indicated that complete recovery of chlorotic symptoms was possible with one spray of 0.5 per cent $ZnSO_4$ spray when the leaves were ½ to 2 months old and with two sprays till the leaves were 3-4 months old. But after the age of the leaves was more than 8 months, no recovery was possible. They also observed that zinc

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sprays did not retain their effect beyond one flush and the zinc content even on the flush immediately succeding the spray is not quite sufficient to keep up the satisfactory level of zinc content. The rate of absorption, translocation and utilization of zinc was higher either with zinc alone or along with nitrogen when compared with that of zinc plus copper.

(b) COMPARISION OF FOLIAR V/S SOIL APPLICATION OF NUTRIENTS TO CITRUS:

In Punjab, Randhawa et al. (1967) reported that zinc applied as foliar spray from $ZnSO_4$ was significantly better than applied ~~as foliar spray from~~ to soil. Similarly iron as foliar spray was more effective than soil application. Singh et al. (1969) reported that zinc spray (0.4 per cent $ZnSO_4$ solution) was better than soil application, they believed that it may be due to more active absorption and translocation of zinc within the plant when applied directly on leaves than when it is added to soil. They further reported that foliar application produced the largest fruit and maximum reduction in acidity.

Bakshi et al. (1969) reported that soil application of zinc proved more effacacious than foliar spray. Manchanda (1970) found that two or three foliar zinc sprays were significantly better than one zinc spray or 5, 10 and 15 ppm zinc applied through soil during the second years. In the authors view this may result of fixation of applied zinc in the soil in the first year, and of ~~result~~ residual and direct availability of zinc in the second year. He further observed that there was a poor translocation of micronutrients from any of the foliar spray treatment into the new flush of leaves, stressing the need of repeated micronutrients sprays every year (Table 8). There was an appreciable movement and accumulation of zinc applied to soil with time in the lower soil horizons. About 1 to 2 years were needed before the zinc applications through soil were effective and zinc application every year may not be necessary.

(c) RESPONSES TO DIFFERENT SOURCES OF NUTRIENTS:

Aiyappa and Subramanian (1959) obtsined a partial recovery of orange plant by using different chelated compounds with fritted copper and sequestrene zinc at Coorg (Mysore).

In Punjab, research studies on effect of different sources of iron on citrus plant indicated significant increases in uptake of iron from different sources, the order of response was Rayplex powder > Chelated iron foliar spray > Rayplex pellets > $FeSO_4$ > Spartin > Control > Fe-EDTA. But in the second and third years of application the order was $FeSO_4$ spray (0.4%) > chelated iron > Fe-EDTA > Rayplex pellets > Control > Spartin Rayplex powder. The mobility of iron in soil was also noticed under Rayplex powder, chelated-iron and spratin sources (Anonymous 1966-1968).

Randhawa and Dev (1968) reported the results of a study on different sources of zinc on citrus plant growth on an alkaline calcareous soil (Table 9).

Table : 9: Effect of different sources and methods of zinc application
on zinc content of citrus leaves

No.	Treatment	Method of application	Average zinc content 1965-66	1966-67
1.	Control	-	9.0	17.8
2.	$ZnSO_4$ solution	Spray	7.6	36.0
3.	$ZnSO_4$	Soil	11.6	24.0
4.	Rayplex (Pallets)	Soil	11.8	27.5
5.	Rayplex (Powder)	Soil	14.6	28.0
6.	EDTA-Zinc	Soil	11.3	27.8
7.	Spartin	Soil	13.2	24.0
C.D. (5% level)			2.30	4.70

They observed that foliar spray of zinc was uperior to various soil applicati. Among soil application, Rayplex powder, zinc EDTA and Rayplex pallets were better sources of zinc than spartin or zinc sulphate.

Khanna et al. (1969) reported maximum absorption of zinc applied as foliar spray and the order of absorption was Zn HAD 7 $ZnSO_4$ / Zn-EDTA. Similar was the case with copper application. Anand et al. (1969) reported that maximum per cent reduction in chlorosis was obtained by zinc-HAD. Higher levels of HAD as chelate of zinc and copper were slightly superior to other salts in reducing chlorosis. EDTA was inferior to all other sources used.

Bakshi et al. (1969) applied different sources of zinc and iron through both the methods i.e. soil and spray and found 50 g of $ZnSO_4$ and 35 g of Zn-EDTA per pot responded to trifoliate orange seedlings but failed to get responses from different iron sources. Arora (1969) found that HAD as zinc source proved better in uptake of zinc than salt of EDTA.

The above review indicates contradictory results regarding the usefulness of foliar and soil application of micronutrients especially zinc to citrus plants. Since zinc is not very mobile and it is not translocated from the older to the young growing tissues, therefore, foliar application of zinc has to be made repeatedly to meet the demand of growing tissues of a deficient plant. On the other hand, the growing tissue can make use of soil zinc if present in sufficient quantity in the root zone. But the ~~xim~~ roots of citrus plants ramify in the sub soil where zinc is not present in sufficient quantity to meet the requirement of the plants. Research studies are needed to be taken up on the following lines:

1. The levels to which the zinc could be built up in the root zone i.e. sub soil.
2. The extent of mobility of zinc salts alone and in combination with different carriers using radiotracer techniques.
3. The residual availability of zinc and other micronutrients from the root zone (sub soil) with the help of raido tracer techniques.

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Table 8: Effect of soil and fol
manganese and iron + m
flush of sweet orange

Treatments	Zn (ppm) Oct. 68	July 69	Cu (ppm) Oct. 68	July, 69	Mn (ppm) Oct. 68
1	2	3	4	5	6
Main treatment					
Control	10.3	15.4	6.9	5.5	75.0
Zn 5ppm	16.6	33.0	7.7	4.8	76.7
Zn 10ppm	21.2	38.9	4.1	4.4	77.3
Zn 15ppm	25.3	42.7	5.5	5.9	82.5
One zn spray	24.7	21.9	6.8	6.4	74.8
Two Zn spray	33.1	19.6	4.7	6.0	80.9
3 Zn spray	35.7	24.9	6.8	5.2	78.0
C.D at5%	5.96	10.60	0.62	-	-
SUB TREATMENT					
Fe spray	21.2	26.6	6.7	5.6	52.3
Mn spray	22.4	28.8	6.1	5.1	97.0
Fe+ Mn spray	27.9	28.8	5.5	5.6	84.3
C.D at5%	-	-	-	-	8.44

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TABLE: 10: Chemical composition
University Farm, Lud

Sr. No.	Name of variety	
1.	Tangerin Dancy Sangtra	1.98
2.	Satsum	2.00
3.	Natal tight	2.19
4.	Lohon Local	2.35
5.	Coorg	1.66
6.	Sweet lime	2.24
7.	Kagzi lime	2.49
8.	Marsh seedless grape Fruit	2.(
9.	Fostle grapefruit	2.04
10.	Pink	1.76
11.	Nanlinco Malti	3.06
12.	Golden Naggrt	2.17
13.	Jaffa	2.18
14.	Mosambi	1.70
15.	Black red	2.156
16.	Hamlin	1.624
17.	Pine apple	2.044

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... 1969 and Kanwar et.al. 1969).

Azad and Bhambota (1966) observed no direct relationship between moisture status of soil horizon and citrus chlorosis. They attributed that citrus chlorosis might be due to effect of soil pH, salinity and alkalinity and nutrients availability which might be affected indirectly by soil moisture content.

Azad and Bhambota (1966) reported that higher the irrigation level required by an inter crop, the higher the incidence of chlorosis observed and vice versa.

Kanwar and Bhambota (1968) while studying the effect of different water tables and salinity levels noticed that 30 cm water table and 6 mmhos E.C. were most harmful to citrus. They found that chlorophyll content of leaves decreased as water table decreased and salinity increased. They further observed that Na content of leaves was almost four times and that of K three times as much as in case of 30 cm water table when compared with 60, 90 and 12 0 cm water tables. Whereas the Ca and Mg content showed the opposite trend. The uptake of Mn, Zn, Fe and Mo decreased at high water table.

f leaves of different varieties/species of citrus grown at Punjab Agri
ana (Anonymous, 1965-66).

	P	K	Ca	Mg	Na	ppm (oven dry basis) Fe	Mn	Cux	Zn	Mo
	0.204	0.98	1.79	0.52	0.15	84	27	8.8	13.8	13.1
	0.215	1.50	1.50	0.64	0.10	89	27	23.8	15.8	13.7
	0.178	1.90	1.13	0.55	0.07	63	22	6.6	16.7	14.5
	0.193	1.20	1.13	0.64	0.08	72	25	4.7	11.0	12.5
	0.168	0.98	1.89	0.46	0.15	73	22	5.3	13.8	12.5
	0.206	1.41	2.32	0.73	0.10	297	65	3.1	13.6	18.7
	0.265	1.56	0.78	0.52	0.04	89	20	12.5	16.0	11.8
37	0.190	1.50	1.97	0.78	0.16	83	23	3.5	36.1	15.0
	0.184	1.50	1.86	0.71	0.27	102	29	5.6	40.0	29.7
	0.186	1.25	10.04	0.44	0.05	69	22	19	17.3	13.1
	0.209	1.44	1.17	0.71	0.11	125	31	5.9	17.5	14.5
	0.181	1.25	1.40	0.69	0.12	115	31	3.1	17.5	15.6
	0.105	1.29	1.17	0.59	0.08	119	30	6.4	9.6	10.6
	0.220	1.53	1.00	0.54	0.06	7[illegible]	30	4.0	8.7	13.8
	0.237	1.17	1.19	0.50	0.08	59	19	4.7	8.4	30.3
	0.189	1.21	1.16	0.50	0.10	105	23	4.7	14.5	16.9
	0.250	1.17	0.87	0.47	0.06	63	16	7.5	21.0	15.0

... of growing tissues of a deficient plant. On the other hand, the growing tissue can make use of soil zinc if present in sufficient quantity in the root zone. But the ~~xin~~ roots of citrus plants ramify in the sub soil where zinc is not present in sufficient quantity to meet the requirement of the plants. Research studies are needed to be taken up on the following lines:

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3. The residual availability of zinc and other micronutrients from the root zone (sub soil) with the help of raido tracer techniques.

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4. The most efficient methods of correcting multiple deficiencies of micronutrients.

No doubt, the above literature indicate significant responses of citrus to micronutrient application, but the yields of plants per tree were very poor and had not gone more than 200 fruits per tree in any case (Bakshi, 1971) whereas the yields under similar situations and of the same varieties reported in foreign literature were of the order of 700 fruits per tree. Excess to toxic amount of boron may be a critical factor for a chieving the potential yield and more detailed investigation on root stock and scion combinations may provide a useful information in this directio

III. Ability to absorb nutrients of different citrus species raised on the same root stock and on the same soil.

Data in Table 10 show that N, P, K, Ca, Mg and Na contents of leaves of different species vary from 1.62 to 3.07, 0.169 to 0.266, 0.98 to 1.90 respectively. The ranges of copper, iron, manganese, molybdenum and zinc are 3.12 to 23.75, 5.4 to 28.91, 15.62 to 54.09, 10.62 to 30.3 and 8.4 to 40.0 ppm respectively.

Studies are needed to find out threshold values of deficiency, sufficiency and toxicity of micronutrients for each citrus variety and root stock scion combinations.

IV. Effect of moisture and salt concentrations on the growth and nutrient uptake by citrus varieties.

a) Effect of moisture regimes

Citrus is sensitive to over moist soil conditions within its root zone and thrives best on soils that are well drained. The fluctuating water table is also deterimental to orchard health and defective drainage caused disturbances of nutritional balance, particularly of iron, in citrus trees.

Bhatt (1945), Naik (1949) and Kanwar and Randhawa (1960) observed that inadequate drainage was one of the important factors responsible for citrus decline in Bombay, South India and Punjab, respectively. Excellent growth of citrus was seen in areas where the water table was below 1.5 meters in all seasons (Singh et al. 1962; Singh and Jawanda, 1963 and Kanwar et.al. 1965).

Azad and Bhambota (1966) observed no direct relationship between moisture status of soil horizon and citrus chlorosis. They attributed that citrus chlorosis might be due to effect of soil pH, salinity and alkalinity and nutrients availability which might be affected indirectly by soil moisture content.

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Kanwar and Bhambota (1969) found that plant growth as determined by plant height, diameter, foliage, root and shoot dry matter and root length was effected most markedly by one foot water table. The differences between 2, 3 and 4 feet water tables were not significant. The most injurious effect was produced by a salinity level of 6 mmhos per cm at 25° C. Worst effect was produced by a combination of 1 foot water table and salinity level of 6 mmhos/cm. The adverse effect of 1 foot water table was more pronounced than salinity levels used.

(b) Effect of salt concentrations

Citrus trees are extermely susceptiable to salt injury and should never be planted on land that has even a slight accumulation of saline material. Particularly in Punjab, citrus is mostly planted in irrigated arid and semi-arid parts of the State. With the introduction of canal irrigation in these areas, the water table has risen, resulting in an accumulation of salts within the root zone.

Kanwar and Bhambota (1968) reported that out of 4 levels of salinity (i.e. 1,2,4 and 6 mmhos/cm in a saturated extract at 25°C), the most injurious effect was produced by a salinity level of 6 mmhos/cm. They also observed that K content was markedly depressed by C_6 and C_4 levels of salinity but Ca showed opposite trend. The Cu and B contents were depressed by the high level of salinity but Zn and Fe showed an increase.

After analysis of large numbers of soil samples from chlorotic and healthy orchards, (Kanwar and Randhawa, 1960; Kanwar et al. 1965) proposed that electrical conductivity of 1:2 soil water suspension should not be more than 0.5 mmhos/cm otherwise growth of citrus would be adversely affected.

Table 11: Electrical conductivity of soils taken from site of normal and chlorite plants at Attari (Amritsar)

Condition of plains	Electrical conductivity mmhos/cm 1:2 soil
Normal	0.15 – 0.30
Chlorotic	0.26 – 3.7

However, in the light of most recent studies, the limit has been revised and raised to 0.8 mmhos/cm. Application of gypsum to sodic soils will decrease the chances of sodium hazard.

Bhambota and Kanwar (1970) further noticed that salt concentration higher than 1100 ppm proved highly detrimental to the growth of sweet orange. Even 500 ppm of NaCl and 600 ppm of Na_2SO_4, whether used alone or in combination proved harmful. At the same concentration, Na_2SO_4 was less harmful than sodium chloride. In the light soil, addition of 2.5 ppm of borax seemed beneficial becaus[e] of the deficiency of borax in the soils. They also found that chlorophyll content [of] leaves decreased with an increase in the concentration of salts. The reduction in [the] chlorophyll [illegible] leaves was accompained by a higher uptake of sodium

chlorophyll content of the leaves was accompanied by a higher uptake of sodium and a lower uptake of Mg and Fe.

Information on salt tolerance of different citrus species can be valuable in diagnosing suspected salt injury in the field, in selecting salt tolerant varieties for saline areas, in determining irrigation and drainage requirements and in employing proper practices for salt affected land. The only work reported in India on salinity tolerance of different citrus pscecies is of Bhambhota and Kanwar (1969). They used four root stocks budded with blood red variety of sweet orange as a common scions and four varieties of sweet oranges on a common root stock of rough lemon (c.jambhiri) for this study. The salt combination used for this comparison contained sodium chloride 1500 ppm, sodium sulphate 200 ppm, sodium bicarbonate 210 ppm and borax 2.5 ppm. The results show that:

Salt tolerance of different root-stocks varied in the order Kharna Khatta, Galgal, Trifoliate orange and Rough lemon.

Out of the various scions budded on rough lemon the salt tolerance varied in the order Hamlin valencia late, pineapple, blood-red.

The blood-red sweet orange which is the most common variety in the Punjab, is the most susceptible varietty to salinity. Even the rough lemon (C.jambhiri) root-stock which is most commonly used is least suitable for such conditions.

Further detailed research on this aspect will be of great value.

SUMMARY

From the above, it can be concluded that in the important citrus belts of India, the integrated effect of soil and sub-soil, on citrus plant has not been studied adquately. Many of the problems of malnutrition of citrus are either due to actual deficiency or low availability of the nutrient in the soil or its immobility in the plant tissue. Evidence exists of wide spread deficiency of micronutrients particularly of zinc and also of iron and manganese whether it is the soil factor alone or soil factor plus the stock scion relationship in a given environment which affects the citrus nutrition. It is suggested that intensive researches on citrus nutrition and fertility problems of citrus soils should be taken up. Ameliorative measures to remove the deficiency of zinc control also be studied critical limits of nutrients keeping in view, stock scion relationship between varieties and soil conditions may be fixed. Salinity, water table and drainage on citrus nutrition needs to be studied - The interaction between diseases and nutrition of citrus also needs attention.

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STUDIES ON THE ROOT SYSTEM OF LEMON (*Citrus limon* (L) Burm.) var. GANDHARAJ. I. GROWTH AND DISTRIBUTION OF ROOTS, THEIR ANATOMY AND NITROGEN CONTENT.

by

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A comprehensive study of root system of fruit plants, particularly the study on the distribution pattern of different types of roots in different soil horizons and depths, is of much importance for elaborating good cultural practices. Knowledge on the internal tissues development and on the potency of different types of roots in relation to synthesis of various organic compounds, on the other hand, is of much help for a clear understanding of the physiology of fruit plants. Although large number of reports are available from other countries on the root system studies of temperate fruits, no significant research has so far been directed towards root system studies of sub-tropical fruit crops like citrus, particularly in India.

Materials and Methods:

Studies were made on the root systems of 8 year old vegetatively propagated (cuttage) lemon (*C. limon* (L) Burm.) trees of Gandharaj variety during 1971. The orchard is located at the Dharampur Campus of the University of Kalyani, West Bengal. The climate of the area is humid subtropical and the soil is neutral sandy loam type. Studies were made on the following aspects.

(a) Root Distribution: The distribution pattern of differ nt types of roots was studies from the record of weight distribution of root mass in the soil layers after uncovering a part of the root system by dry excavation. For this, a circle with a readious of two metres (from the trunk) was marked round the tree and the soil was excavated from 1/8th portion of the area - for collecting

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the root samples. The two-metre radius was subdivided into four parts, each having fifty cm. width, and the area covered under these radii were designated as different 'horizons' (H_1, H_2, H_3 & H_4, as in Fig. 1). Roots were collected from two soil depths. e.g. 0-25 cm. and 25-50cm. and the depths were designated as D_1 and D_2 respectively (Fig.I). Root collections were made separatefly from each such horizons (of each depth) after quick washing out of the soils by water on fine meshed seives and were brought in the laboratory for measurements etc. The roots thus collected were categorized in six groups according to their thickness (basal girth) 0-1 mm, 1-2mm, 2-3mm, 3-4mm, 4-6mm and 6 mm and above. Fresh and dry (after 24 hours oven drying at 80 ^oC) weights of the root samples were recorded. The length of an unit weight of a particular type of root (thickness group) was measured and the total length was calcualted thereafter with the help of respective coversion factors.

(b) Nitrogen and free amino acid contents of roots:

Total nitrogen contents of the roots were estimated from dried samples by micro-kjeldahl method. Free amino acids present in the roots were analyzed semi-quantitatively by two dimensional paper chromatography by using water-saturated phenol and butanol-acetic acid-water (4: 1 : 1, v/v) as solvent systems. Amino acids were analyzed from different types of roots of D_1 depth. 5 gm samples (fresh weight) were taken for extractions of amino acids.

(c) Microscopic studies of the roots:

The degree of development of translocating vessels (Xylem) in the roots of different thickness was recorded from the transverse sections. The sections were first stained in Saffranin and then in Fast Green and were finally mounted in Canada Balsam (Herrero, 1951) Each transverse section was divided into four equal quadrants and from each quadrant the number of xylem vessels were counted from microscopic fields of 45 x 10 magnification. The average of such four readings was considered as the number of xylem vessels in the unit area of the transverse suface of the particular type of root. Radial diameters of the vessels were always measured in a particularl direction (from cortical end towards centre) and the average diameter was calcualated by considering the wood part of the roots as circles. All measurement were made with the help of a ocular micrometer.

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Results

(a) Distribution of various types of roots in Soil: The vertilca penetration of the roots could be traced upto a depth of even more than a metre. After tracing a few number of main roots from the trunk it was observed that the main roots did not penetrate in a strictly vertical fashion, but with frequent bends, particularly at deeper regions of the soil. This bending of the main roots made the accurate measurements more difficult and upto a depth of one metre the length could be measured comparatively accurately. However, from the thickness of the roots at such a depth it was apparent that the the roots might have penetrated only a few more centimetres and in any case it should not be more than another fifty centimetres.

The horizontal spread of the roots was ascertained after tracing back a few well developed roots from the trunk and towards the periphery, It was noted that the roots had a spread of more than two metres from the trunk. At a distant of two metres, only very thin types of roots were noticed.

From the Table 1, it is clear that all the types of roots were found only upto a distance of one metre (H_4 & H_3) from the trunk and that was also of the first depth (D_1) of soil. Roots of 6 mm and above thickness were not present in any case beyond this one metre distance and in the comparatively distal horizones (H_1, H_2 and H_3) of D_2 depth thicker type of roots (4mm and above) were absent. In the D_1 depth, maximum amount of thinnest type (0 - 1 mm) roots was concentrated in the most distal horizon (H_1), whereas in the D_2 depth maximum concentration of this type of roots was noticed in H_2 horizon; in the H_1 horizon of D_2 depth the presence of thinest type of roots was of very insifnificant proportion. From the Fig. 2, it is apparent that major amount of roots of different thickness were confiened in the surface layer of soil (D_1 depth) and the total length of thinner fibrous roots was many fold more in the D_1 depth of soil than in the D_2 depth.

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Table 1 Total length of roots of different thickness at different soil horizons and depths(c

Thickness of roots(mm) \ Depth & horizon	D_1 H_1	H_2	H_3	H_4	Total D_1	D_2 H_1	H_2	H_3	H_4	Total
0 - 1	7719.71	6061.6	266.3	8167.5	2215.1	180.0	2325.0	1320.0	2175.0	6000.0
0 - 2	1689.3	1660.3	174.3	426.6	4155.6	112.5	-	180.9	207.8	614.0
2 - 3	295.6	291.7	57.4	169.1	814.7	-	-	80.6	87.7	168.3
3 - 4	182.6	35.3	24.0	81.8	331.7	-	53.0	-	30.8	30.8
4 - 6	-	61.9	96.8	206.0	365.4	-	-	-	80.0	133.0
6 & above	-	-	81.7	300.0	382.7	-	-	-	73.0	73.0

Interestingly enough that in a 8 year old lemon tree only in 1/8th portion of total surface area and upto depth of only 50 cm. of soil, total length of the root was approximately as high as 360 metres. In other words it may be said that upto a soil depth of 50 cm a vegetatively propagated bearing lemon tree has got roughly (360 x 8) 2880 metres of root.

Nitrogen content in the roots:

Estimation of total nitrogen content of the roots of different thickness indicated that the thinnest type of roots (0 - 1 mm) had highest percentage of nitrogen all all the soil horizons and depths. Interestingly, the average nitrogen content of the roots of upper layer of soil (D_1) was markedly more than that of the roots of lower layer (D_2). There was also some differences in the nitrogen contents in the roots of different horizons, and the roots closest to the trunk (H4) had maximum percentage nitrogen. As the roots of 0-1 mm and 1-2mm thickness were present in all the soil horizons and depths, only these two groups of roots were considered for the calculation of average nitrogen content of the roots of different individual horizons and depth (Fig. 4).

Table 2. Total nitrogen content in the roots of different thickness at different soil horizons and depths (% dry weight)

Thickness of roots (mm) / Depth & Horizon	D_1 H_1	D_1 H_2	D_1 H_3	D_1 H_4	D_2 H_1	D_2 H_2	D_2 H_3	D_2 H_4	Average
0 - 1	4.77	4.77	3.39	3.01	3.30	3.32	4.65	4.06	4.28
1 - 2	3.96	4.[illegible]4	1.94	[illegible].44	2.71	1.74	2.54	2.57	2.80
2 - 3	2.95	3.39	1.74	3.03	–	–	2.06	2.78	2.[illegible]1
3 - 4	2.35	2.22	1.3[illegible]	2.00	–	–	–	2.33	2.35
4 - 6	–	2.23	2.66	3.63	–	2.37	–	1.08	2.57
6 & above	–	–	4.36	3.41	–	–	–	2.83	3.54

N content of D_1 roots (av. of 0-1 mm and 1-2 mm roots) = 3.04%
N " " D_2 " (" " " " " " " ") = 3.01%
N " " H_1 " of D_1 and D_2 (av. of 0-1 mm and 1-2 mm roots) = 3.71%
N " " H_2 " " " " " (" " " " " " " ") = 3.51%
N " " H_3 " " " " " (" " " " " " " ") = 3.13%
N " " H_4 " " " " " (" " " " " " " ") = 3.00%

Free amino acids:

Nine different free amino acids could be detected from the roots of different thickness, namely - Aspartic acid, serine, Glycine, Glutamic acid, Threonine, Tyrosine, Histidine, Valine and Proline. Of the nine amino acids, the presence of three e.g. Histidine, Valine and Proline is doubtful or they are present in very minute quantities. It seems that for the confirmation of their presence it is essential to test with more concentrated extracts from larger quantity of root samples. From the chromatograms, it was apparent that there was no marked difference in the amino acid composition inthe roots of different thickness.

Anatomy of roots:

From the table 4, it is clear that thinner types of roots had comparatively higher number of translocating vessels per unit area of the wood. However, it needs to be mentioned that the total wood are (Central cylinder) was more developed in the thicker roots in comparison to that of thinner ones and therefore the total number of vessels in the whole transverse surface was more in the thicker roots. The size of the vessels, as indicated by the measurements of radial diameters of the ..... cells, was significantly larger in the thicker roots, largest being noted in the roots of 4-6 mm thickness and smallest in 1-2 mm roots. Bark-wood ratio was same in 1-2mm and 2-3mm types of roots (being 1.3, in both types), whereas it was 0.9 and 0.3 in the roots of 3-4 mm and 4-6 mm thickness types respectively.

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Table 3. Free amino acid contents in the roots of different thickness at different soil horizons of D_1 soil depth.

Root thickness & soil horizon & soil horizons / Amino acids	0 - 1 mm				1 - 2 mm				2 - 3 mm				3 - 4 mm			
	H_1	H_2	H_3	H_4	H_1	H_2	H_3	H_4	H_1	H_2	H_3	H_4	H_1	H_2	H_3	H_4
Aspartic Acid	++	++	++	+	+	+	+	+	+	+	+	+	+	+++	+	+
Serine	+	+	=	+	+	+	=	+	+	F	F	+	++	+	+	F
Glycine	+	+	+	–	+	F	F	F	++	+	F	F	+	F	–	F
Glutamic Acid	+	+	+	–	++	–	–	F	+	F	–	–	+	++	G	–
Threonine	+	+	F	+	+	F	–	+	++	F	F	+	+	+(?)	+	F
Tyrosine	+	–	–	F	+	F	+	F	+(?)	–	–	F	+	+(?)	+	F
Histidine	F	–	–	–	–	–	–	–	+(?)	–	–	–	+(?)	–	–	–
Valine	–	–	–	–	–	–	–	–	–	–	–	F	–	–	–	F
Proline	–	–	–	–	–	–	–	–	–	–	–	–	–	–	F	–

F – Faint
? – Doubtful.

Table 4. Some anatomical charactetististics of roots of different thickness.

Thickness of roots (mm)	Diameter of roots (/u)	Bark-wood ration	No. of xylem vessels in the microscopic field (ocular 10, objective 45)	Total No. of vessels in the whole T. S.	Radial diameter of xylem vessels (/u).
1 - 2	1157.2	1.3	23	67	49.2
2 - 3	2472.2	1.3	17	221	54.5
3 - 4	3287.5	0.9	11	376	69.7
4 - 6	4976.5	0.2	9	1163	74.0
S. E. M. ±			0.6		1.52
C. D. at 5%			2.28		5.26
C. D. at 1%			3.14		7.97

DISCUSSION

Bearing lemon trees raised from stem cuttings have shown to develop vertical roots upto a depth of about a metre and lateral roots upto two metres from the trunk at an age of about 8 years. From the analysis of the data on the distribution pattern of various types of roots in the soil, it was further noted that the upper layer of soil upto a depth of 25 cm had comparatively much more amounts of roots than the lower layer (25 - 50 mm). It was also observed that out of the total amount of thinner roots (0 - 2 mm thickness), about 80% is located in the upper soil layer only. Now, considering the fact that most of the absorbing roots are located on the thin fibrous roots or fall under the above mentioned thickness group, it can be concluded that in lemon also, as in many other fruit crops, a major part of the absorbing roots are concentrated in the upper layer of the soil or in the surface soil.

The results on the growth of roots and their distribution pattern are in conformity with the results of other workers like Savage et al. (1945), Ford (1955) and Aiyappa et al. (1968), who studies the root systems of various types of citrus. Thus, Savage et al reported that rough lemon root stocks had a horizontal spread of about 5 ft. and vertifal penetration of about 3-4 feet.

From the similar type of study on the root system of mandarin orange seedling plants of 2½ years old, Aiyappa and Srivastava (1968) observed that the top root penetrated vertically upto a depth of about 224 cm and laterally to about 351 cm. The better vertical and lateral growth of roots as observed by Aiyappa and Srivastaya (1968) may be due to fact that the plants they studies were raised from seeds and as such the tap root must be well developed. Moreover, the difference in the roots growth may be linked with differences in the species characters of the two types of citrus that were used as experimental materials. Savage et al (1945) noted that sour orange developed more deeper root system than rough lemon.

Total nitrogen content has been found to be more in 0-1 mm type of roots and it was also noted that the roots of the upper layer of soil (D_1) had higher nitrogen content, in comparision to the roots of lower soil layer (D_2). The higher nitrogen content in the thinner roots may either be due to more deposition of inorganic nitrogen absorbed from the soil or may be due to the presence of

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more organic nitrogen, which has been converted from the absorbed inorganic form. The higher nitrogen content of the roots of upper soil layer might have corelation with the high nitrogen content of the surface soil.

From the microscopic studies of the transverse sections of the roots, it was evident that in the thinner roots (upto 2-3 mm thickness) the cortical zone was more developed than the wood part, while in the thicker roots wood part was much more developed than the cortex. The anatomical studies also clearly showed that the thicker roots had large number of well developed xylem vessels in the wood, while in the thinner roots cross sectional area of the vessels was much less developed.

These differences in the anatomical positions of different types of roots must be linked with their differential functional activity.

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Legends of the Figures:

Fig. 1 - Distribution of roots and the sites of sampling:
A. Representation of horizontal and vertical roots
B. Portion excavated for root collection

Fig. 2- Total length of roots of different thickness at different soil depths.

Fig. 3- Nitrogen content of roots of different thickness.

Fig. 4- Nitrogen content of the roots of different soil horizons and depths(av. of roots of 0-1 mm and 1-2 mm thickness).

ABSTRACT

Studies were made on the growth and development of root system of 8 year old lemon treds of Gandharaj var. under field conditions. The measurements of root length and the determination of root weight indicated that vast majority of the roots are confined in the surface layer of soil (Upto a depth of 25 cm) and at the distalpart (at a distance of 1.5 - 2 metres) there was maximum concentrations of thinner roots (0 - 1 mm thick). Microscopic studies on the degree of development of translocating v vessels of wood revealed that the ticker roots (3 - 4 mm thick) had larger sized vessels, while the thinner roots had more number of vessels per unit area. Bark-wood ration diminishes as the root becomes thicker. The roots of upper soil layer (0 - 25 cm) had markedly more total nitrogen content than the roots of deeper layer (25 - 50 cm). Also, thinner roots contained higher percentage of nitrogen in comparison to the thicker roots. Paper chromatographic studies indicated the presence of nine free amino acids in different types of roots of upper soil layer.

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ALL INDIA SEMINAR ON CITRICULTURE

NAGPUR - 1972

ORCHARD MANAGEMENT PRACTICES AND CROP REGULATION IN RELATION TO FLOWERING, FRUIT SET & FRUIT DROP

By

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The methods adopted for successful management of citrus orchards mostly depend on physical qualities of the soil, the amount of fertility, available moisture supply and climate of the area. The cultural practices followed must help to keep the soil loose and friable during active and maximum growth so as to supply air freely to the roots. In the choice of methods due consideration has to be given to the requirement of the particular soil, since the orchard soils vary considerably in their character. Another important aspect of the growth and development of the citrus trees which should be always borne in mind in soil management is the shallow nature of the fibrous or feeding root system produced by the tree. The root system of mandarin and sweet orange tree is observed to be restricted between 10 to 60 cms. of the soil depth.

In the young orchards, till the trees are 4 to 5 years old, a large part of the land between the rows remains fallow and is generally utilised to grow an inter crop with a view to supplement the income from the area. The intercrops grown usually are either leguminous or non-leguminous depending on the suitability to the soil and climate of the area. Growing of a green manure crop during this period would be advisable, since it will help to build up a good reserve of organic matter in the soil. The practice of soil management adopted during the earlier years should aim to encourage maximum vegetative growth and to achieve this objective timely supply of nitrogen to the plants is essential. As a safeguard against the adverse effect of the intercrop on the growth of young plants it is also necessary to add enough fertilizers to meet the requirements of the crop grown.

With the increase in the height and spread of the trees, the area available between the rows of the trees gradually declines and the shade under the tree canopy does not permit the growth of any crop. The methods of soil management in older orchards generally practiced by growers fall under the

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categories of clean cultivation through out the year, clean cultivation with cover crop and no cultivation at all.

The clean cultivation throughout the year by frequent removal of weeds and regular cultivation is being practiced by most growers. The practice of clean cultivation, though beneficial in making the soil loose and thereby increasing its water holding capacity, results in the formation of a hard pan if the cultivation is done repeatedly at a particular depth each time. Besides, the frequent cultural operations also cause damage to the roots system thereby adversely affecting the tree growth. It is also a well established fact that constant cultivation reduces the soil fertility by causing deficiency of humus and this effect is ultimately exhibited in unhealthy condition of the tree. The tillage when done for burrying the green manure crop, destruction of weeds or to loosen the soil for opening of irrigation furrows should be as shallow as possible. When clean cultivation is adopted as regular practice, the humus content in the soil need necessarily to be maintained with a liberal supply of organic matter. The formation of hard pan which hinders the penetration of water to the lower layers of the soil can be avoided by varying the depth of ploughing or cultivation each time.

One account of the shallow root system is generally recommended not to cultivate the soil in the citrus orchard. Though this practice may be satisfactory for adoption in the heavier and retentive soils, it is not suitable for shallow soils naturally deficient in moisture. Provision of proper drainage is most desirable in the moist retentive soils for the improvement of soil structure, lowering of water table and improvement in the depth of rooting.

The practice of clean cultivation alongwith a cover crop is perhaps an ideal method of soil managementfor the citrus orchards. The leguminous cover crop grown during the rainy season between the tree rows together with the application of phosphatic fertilizers produces a great bulk of green material which when turned into the soil considerably enriches the humus contents. The cultivation of land during the rest part of the year helps in the control of weeds in addition to keeping the soil loose and friable. The multching of soil between the trees also helps to conserve soil moisture during the period of drought and prevents the weed growth. For the soils deficient in moisture or in areas experiencing drought, the practice of multiching proves very beneficial.

Flowering behaviour in different species of citrus is greatly influenced by the environment. While some citrus fruits produce flowers more or less throughout the year, most of them have one or two distinct flowering seasons. For the development of the reproductive tissues, it is essential that the level of carbohydrates must increase within the tree. The low temperatures prevailing in Northern India, naturally check the vegetative

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growth which results in the accumulation of carbohydrates and thus help in the production of flower and fruits on the tree. In contrast, under the climatic conditions of the southern India, being favourable for continuous growth, the increase in the level of carbohydrates within the tree is achieved by reducing the vegetative growth or by giving the so called induced rest to the trees.

The cultural practices followed in the earlier years are therefore, required to be modified when the trees begin to bloom and bear fruits. The citrus trees which otherwise would have produced flowers and fruits throughout the year are regulated to produce fruits in a particular season. In order to induce trees to bloom in a particular season, to control the time of maturity and to increase the yield of fruits a distinct cultural practice commonly referred to as the 'Resting treatment' is adopted. In this treatment the trees after the harvest of the fruits are subjected to severe moisture stress from which they are released either by irrigation or with the advent of summer monsoon rains. The blooming of trees may commence early or later depending on the physiological differences as effected by the nutritive condition within the tree as a result of the severity of the stress. All the trees in an orchard do not flower at the same time and the period of blooming as observed in Nagpur santra extends from 18 to 32 days during both the Ambia and Mrig bahars (2 and 3).

Fruitfulness in various citrus fruits varies greatly with species, varieties and environmental conditions. Although citrus trees usually produce heavy blooms, only a comparatively small percentage of flowers produce mature fruits. Inspite of drop of many flower-buds and flowers, the fruit set is seen to be considerable, but a majority of the set fruits drop down before reaching maturity. The drop of flowers and fruits in different citrus fruits has been observed to be a continuous process from the time of flowering until the harvest of fruits.

✓ Observations recorded on normally bearing Nagpur Santra trees during Ambia bahar fruiting season showed that out of nearly 30,000 flowers produced on the trees, 78% flowers set fruits, but the ultimate retention of fruits till harvest was only about 4% of the fruits set. In Mrig bahar fruiting season, however, out of nearly 15,000 flowers produced on the tree, 76% flowers set fruits and the ultimate retention of fruits was about 20% of the fruits set (2 and 3). In respect of matured sweet orange trees, Randhawa and Dhinsa (4) observed 42% of total blossoms setting fruits and subsequently 3.3% of the fruit retained on the tree after summer drop. Under Punjab conditions, Shambota and Uppal (1) observed the initial fruit set to be 54.22% in Malta blood red and 63% in Mosambi, whereas the ultimate fruit retention was 4.7% on Malta blood red and 4.17% on Mosambi trees.

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The factors reported to be responsible for affecting the fruit set in citrus trees include the nature of flowers produced by the tree, pollen fertility or defectiveness of pistils and the relationship between the leaf surface and the number of fruits. In respect of Nagpur santra, the percentage of perfect flowers borne on the tree is nearly 85% and the pollen fertility is also very high and as such there is no problem of reduction in fruit set on this account. The vigorous growth of the tree and the retention of old leaves, which reflect additional moisture and nutrition are , however, necessary for satisfactory setting of the fruits. The flowers produced on leafless shoots have a poor ability to set fruits as compared to the shoots on which the ratio of leaf area to the number of flowers is high. The observation recorded on santra trees have shown that terminal branches produce more shoots, leaves, flowers and set fruits more than the lateral ones. A positive co-relation between the leaf area and flowering in sweet oranges and grap fruit has also been indicated by Randhawa and Dhinsa (4), Randhawa and Sinha (7) and Randhawa and Khanna (5) under Delhi conditions.

A very heavy bloom on the tree results in failure of the crop on account of the exhaustation of Nitrogen supply by the excessive flowering. The shedding of flowers and fruits not only reduces the potentiality of the crop, but its continuous occurrence results in exhaustion of the tree beyond the possibility of recovery.

Dropping or shedding of fruits is a normal process of adjustment by which fruits in excess of the number the tree can mature are discarded. All the flowers and fruits that fail to mature do not drop at one time, but there are certain periods of dropping of fruits commencing from their development till maturity and as such it is considered to be more or less a continuous process. Randhawa and Singh (6) under Delhi conditions observed two definite periods of fruit drop in Nagpuri and Lahore local varieties of mandarins during April to May and September to October. In addition to these periods of fruit drop, another drop of half grown immature fruits was also noticed to occur soon after the summer or June drop. The observations recorded in respect of Nagpur santra during Ambia bahar season indicated that there are four definite periods of fruit drop namely post-setting (February-March), summer (April-May), premature (June-July) and pre-harvest (September-October) drops. However, during Mrig bahar season only one distinct period of post-fruit-setting drop was recorded during the period from middle of August to middle of October.

There are certain critical periods through which the fruits have to pass before reaching maturity. The maximum percentage of drop of newly set santra fruits in the course of post-fruit-setting period in both the Ambia and Mrig bahar seasons is mainly seen to be caused due to greater competition for food

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material by the large number of fruits set on the tree. High temperature accompanied with low humidity and high dessicating winds during summer cause excessive transpiration in the tree and under such conditions, the leaves actually draw water from young fruits. The transpirational demand of the tree under such conditions becomes greater than the absorbing and conducting system of the tree can meet and such water deficit thus caused in the tree accentuates the fruit drop.

Fruit cracking a serious problem in mandarin orange, pommelo, limes and lemons in North India has been reported to occur during the months of heavy rainfall and high humidity. Dry periods followed by heavy rains and high humidity cause thecracking of santra fruits. Fruit drop due to fruit sucking moth is also a serious problem in different citrus species all over the country.

The total number of seeds as well as the normally developed seeds have been noticed to be more in santra fruits retained by the tree as compared to those in dropped fruits. Similar evidence has also been recorded by Randhawa and Singh (6) in picked and dropped mandarin fruit of Nagpur and Lahore local varieties. It is further suggested by them that the low auxin content in the seeds may be responsible for the drop of immature fruits. The use of sprays of growth regulators like NAA, GA, 2, 4-D, 2,4,5-T and 2,4,5-TP has been reported to be effective in reducing the drop of immature fruits. Results of a preliminary trial with Nagpur santra suggest that the pre-harvest drop of Ambia bahar fruits can be effectively checked by sprays of 10 ppm. NAA or Gibberellic acid applied in the second week of August.

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Item No. 4(ii)

ALL INDIA SEMINAR ON CITRICULTURE

NAGPUR - 1972

SOME SUGGESTIONS TOWARDS MANDARIN ORANGE GROWING (WITH REFERENCE TO DIE-BACK PROBLEM)

By

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Die-back disease of citrus can be considered as a complex involving more than one factor or factors. A set of factor or factors responsible in one region may or may not be involved in another region. The primary cause of one region may be the secondary cause in another region. The secondary cause may or may not be dominating over the primary cause and vice-versa (Aiyappa et al 1971). It is quite evident from the present state of knowledge and also from the work done on the die-back problem that the growers, extention workers, as well as the research workers should bestow maximum attention to all the aspects of scientific citriculture. Factors like unsuitable soil and environmental conditions, improper and infected planting material, defective cultural practices, attack of diseases and insect pests (including viruses and nematodes), mal-nutrition of trees (for both macro and micro nutrient elements) etc have been attributed by different workers.

If careful thought and application of scientific knowledge are given to various aspects, there is no reason why mandarin orange groves should not thrive well and prove to be a remunerative industry in our country.

In this paper some suggestions and brief account of growing of Santra orange on scientific lines are given.

Climate

Environmental conditions have an important role to play in the successful citriculture. Mandarins in general have a wider range of climatic adaptation than other citrus group. The Santra oranges are grown at elivations between about 300 meters-1500 meters(1000'-5000') from the mean sea level and relative atmospheric humidity ranging between 55-100% and with annual rainfall between 1000 mm to 3750 mm (40"-150"). In Coorg and Wynaad areas in the South and in Assam they are grown purely under rainfed conditions while

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in Nagpur areas in Maharashtra are grown under irrigation. The best performing mandarins orchards in Coorg tract are located in the altitude ranging between 600-900 mm(2000-3000") mean seal level and the rainfall ranging between 1500-2500 mm (60-100") per annum. While in Nagpur region the Santras are grown in areas under altitude 307 mm(1025') from mean sea level with relative humidity of 53%, temperature 43°F-117°F and annual rainfall 1125 mm(45")(Aiyappa and Srivastava 1970). High temperature, dry winds, heavy rains abrupt fall in temperature are some of the climatic elements attributed as one of the predisposting factors for the decline of citrus (Narasinga Rao, 1948, Singh and Bakshi 1958, Ramakrishna 1954, Nauriyal 1955, Aiyappa 1959, Aiyappa and Srivastava 1967). It is suggested that a consideration should be given to these factors while undertaking Santra growing and ameliorative measures adopted in advance.

Soil conditions

Unsuitable soil conditions have been considered as one of the contributory factors leading the citrus trees to decline (Cheema and Bhat 1928, Gandhi 1956, Naik 1949, Narasinga Rao, 1948). Clayey and sticky soils, soils with excess of lime, hard pan, shallow and rocky soils, water-logged areas, and soils with low water table with poorly drained conditions have been reported by many workers as one of the causes for the citrus decline. Therefore proper selection of orchard site with adequate soil conditions such as well drained, deep, loamy or sandy loam soils may be preferred. 'Marl' soils having excess of lime etc should be avoided. Stiff, deep, black cotton soils which crack badly during summer are also not suitable. Citrus trees are very sensitive to high salt concentration in soils. Soils and irrigation water containing large amounts of salts should be avoided. Soils with pH ranging between 5 and 8 are considered to be good for citrus. But for successful santra growing, pH between 6.0-6.5 is to be preferred.

Around Nagpur area mandarins are being grown mostly in black clay soils, which are shallow and poorly drained in some localities. The soil pH of these areas usually ranges between 7.0 to 9.0 under which conditions micro-nutrient deficiencies may arise and in some localities 'N' deficiency has also been reported.

Proper plant material/root stocks.

Malpractices in nurseries and improper plant material have also been ascribed as one of the factors responsible leading the trees to decline in the later stage. Plant material free from Phytophthora and free from virus

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infections and of nucellar origin must be selected. Nursery inspection scheme and bud wood certification programme may be strictly followed.

So far, root stock trials conducted for Mandarins in Coorg have shown that the stock Rangpur lime, Sweet lime, Poncirus trifoliate, Cleopatra mandarin, Kodakithuli and Rough lemon are quite promising and seem to withstand decline better. Rootstocks Rangpur lime, Sweet lime, Cleopatra mandarin, Kodakithuli can be recommended for medium clay soils, Poncirus trifiliata for black clay and nonsaline soils, while Rough lemon (C. jambhiri) may be preferred in light sandy loam soils for santras. Jambhiri strains should not be used as rootstocks for Mosambi and Maltas due to their susceptibility to bud-union crease-disorder. More rootstocks trials, taking into consideration the viruses involved are needed to be conducted.

Planting and care of young orchard.

After having selected good, healthy, disease free plants from reliable nurseries, they are planted in orchards located in favourable soil and environmental conditions. Pits 2'x2'x2' may be opened at a spacing of 20 x 20'. In case trifoliata rootstocks are used, the spacing can be reduced to 15' x 15' or 18' x 18'. For filling the pits, good top soil mixed with well decomposed cattle manure can be used. While planting only single stem plants with good root system should be selected. Immediately after planting the tree basin may be mulched with dry leaves and copiously watered. The irrigation beds should be so prepared that water should not come in contact with the tree trunk at any time in order to avoid stump rot and root rot troubles. In Phytophthora root rot infected areas, it is good to fumigate or treat the planting pits with fungicides (1% bordeaux, Captan, Vapam etc.) at least a month earlier to planting.

Pests and disease control.

Proper plant protection measures against diseases and pests are very important. Among diseases stump rot, root rot (Phytophthora sp.) powdery mildew, anthracnose, sooty mould etc. and among insect pests, stem borers, bark eating caterpillars, aphids, scales, psylla are very harmful and they have been already reported to be one of the factors involved in the die-back problem. Training the trees to single stem to a height of 1½'and periodic application of 1% Bordeaux paste to the trunks to prevent foot rot troubles may be adopted.

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Proper cultural operations

Inter-culture, weeding, mulching etc. Root distribution studies in matured mandarin trees conducted at Gonicoppal centre indicated that about 28% fibrous, 21% thin, 12% medium thick and 40% thick roots of root system confine to 0-30 cms depth and therefore deep digging with mumties may be injurious to citrus roots and may lead to root rot infections. Digging, scuffling or forking may be done to a depth of 3-4" (7-10 cms) for the purpose of providing soil mulch, or for better soil aeration, or while incorporating manures and fertilizers. For controlling weeds during heavy rainy seasons, slashing of weeds with sharp dabba blades can be done and finally after the rains, the weed growth around the tree basin are scraped and are used for mulching the tree basin from trunk to trunk. Faulty management and improper cultural operations such as deep digging,indiscremate clean cultivation practice allowing shrubby growth of weeds in citrus orchards should be avoided. Root pruning or 'bahar' treatment which is generally practised in Nagpur area for forcing flowering has been opined to be detrimental to the tree, and the root injuries so caused, become prone to the attack of Phytophthora and they succumb to root rot diseases. Such cultural practices need further probe and proper methods should be evolved.

Manuring, Fertilization and Micro-nutrient sprays: Neglect of citrus orchards without manuring and fertilization lead to mal-nutrition of trees, detrioration in vigour, and as a result they become susceptible to the attacks of diseases and pests. The role of micro-nutrients and their implications in plant nutrition are not made known to the citrus growers. Improper plant nutrition has been reported to be one of the major factors responsible for the cause of the decline.

In Coorg area the manurial recommendation for mandarins is to supply approximately 0.04 kgs N, 0.04 kgs P205, 0.01 kgs K20 per tree per year from first year and then increasing by 0.08 N, 0.08 P205, 0.07 K20 to 0.5 N, 0.33 P205, 0.54 K20 for mature trees. And for bearing trees approximately 0.55 N, 0.37 P205, 0.55 K20 kg per tree per annum applied in 2-3 split doses. One third of the quantity may be applied in organic form. Foliar nutrition ofZn, Mn, Mg are being recommended as a regular practice in Coorg. In Maharashtra areas deficiencies of Zn, Mn, Mg and N have been reported and this must be supplimented by way of proper fertilizer programme and foliar sprays based on soil and leaf analysis recommendations.

Irrigation, moisture conservation, drainage and salinity: Water-plant relationship is as important as soil-plant relationship. It has been found that most of the productive

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and healthy green citrus orchards are those which are maintained under optimum soil moisture level. In India Santra orange is being grown under irrigation regime except in Assam, Coorg and Wynaad areas, where they are grown under rainfed conditions. It has been reported by many workers that severe water stress during summer generally in black clay soil areas and also poor drainage in heavy rainfall tracts are ascribed to be one of the factors leading the orchards to decline. Due to water stress, the root activity is reduced, and as a result, availability of nutrients as well as root absorption is checked, leading to stunted grow h, yellowed or mottled leaves and die-back of twigs. Excessive watering, as well as swampy condition lead to root decay and die-back. The intervals of irrigation depends on soil nature texture, water holding capacity and seasons of growth and crop condition etc. For proper economical utilization and conservation of soil moisture (both under irrigated as well as rainfed condition) mulching or covering the tree basins may be beneficial. The irrigation water must be analysed for salt concentration. High salt content in irrigation water as well as in the soils cause accumulation of salts or develop salinity condition at the root zone and may cause root injuries and trees may start declining. In such cases reclamation of soil may be very important before taking up planting. It is reported that lack of irrigation water is the major bottleneck in the mandarin growing in and around Nagpur areas (Jawanada 1969).

<u>Inter-cropping</u>:- Although intercropping in citrus orchards has its own advantages and disadvantages, taking intercrops may be restricted to the pre-bearing period of the citrus trees. Short duration crops like tomatoes, beans, peas, carrots, onions, potatoes, pulses, gram etc. can be taken up. In Coorg area, pineapple, ginger, termeric are being recommended as inter-crop for a period of 3-4 years only. It has been reported that in Punjab, inter-cropping is one of the causes for citrus decline. It is stated that growing Sugarcane, Wheat, Maize, Jowar, Bajra etc. as inter-crops are harmful to citrus (Bajwa and Ali, 1945, Chada et al 1970). Proper spacing must be given between the main crop tree and the inter crop rows in order to avoid root competition. The growers should bear in mind about the deleterious effects of inter-cropping for unusually a long period on the citrus trees. In many cases, it, so happens that the growers become more interested in the inter-crops rather than in the main citrus trees in their orchards and start neglecting the citrus as secondary or subsidiary crop position. Such implications on the part of the growers are dangerous to citrus industry.

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Pruning of dried twigs:- Twig drying is generally noticed in young as well as in old citrus trees. In certain areas especially in heavy rainfall tracts big branches may also be found dried up due to bark disease like pink disease or Anthracnose, or due to Diplodia sp. Fusarium sp. etc. . Severe drought condition also may cause twig drying. Some infestation of scales, citrus psylla, mites etc. are also found to cause drying of young shoots. A slight wave of phytophthora leaf fall and fruit rot disease do cause severe leaf shedding and twig drying, and in some cases big branches also dry up. Pruning is an essential feature of a good orchard management and should be included as a annual practice in the orchard maintenance programme.

Pruning not only helps to improve the sanitary condition of the trees, but also envigorates them and encourage good, healthy shoot growth and vigour. Pruning can be done soon after the crop is harvested. Sharp secatures and good hand saw can be used for this purpose. Bordeaux pasting may be advantageous for swabing big, cut surfaces and wounds. Pruning of yellowed or mottled shoots in any healthy green trees may be advisable. This practice may help to reduce the concentration of greening virus (Mycoplasma like bodies) in trees since greening is reported to be present in localised condition in the tree and not easily translocated. All prunings and dead branches must be burnt to avoid them from becoming sources of future infection.

Virus diseases and their control:-

In recent years the citrus decline has taken a new dimension. Involvement of viruses like tristeza, greening, stuborn etc. have been reported to be present in all citrus zones in the country. Eradication or complete control of these viruses is not easy but they can be kept under check to a greater extent with less tree decline and apparantly in good productive condition by using resistant or tolerant rootstocks and by using nucellar line plants in future orcharding. There is no single rootstock in citrus that is resistant or tolerant to all the citrus viruses. Therefore, recommending a particular rootstock against a particular virus is only a temporary measure. Rootstocks like Poncirus trifoliata, Rangpur lime, Cleopatra mandarin, Kodakithuli, Troyer citrange, Sweet lime and Rough lemon and even certain Sweet orange varieties (where root rot is not common) need attention.

Besides these, the orchards must be maintained under perfect sanitary condition by adopting timely spray schedules particularly against citrus Aphids and Citrus Psylla which are common virus vectors.

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Suggestions for future line of work.

1. Greater emphasis is needed to improve and to maintain the quality of the plant material at the citrus nursery. Methods are to be deviced to produce nucellar seedlings in large numbers for distribution. Bud-wood certification programme should be strictly introduced.

2. In the future the rootstocks may be used with perspective to disease resistance especially for Phytophthora root rot and stump rot and also certain virus diseases. More tolerant or resistant rootstocks may be evolved by taking up more trials at different zones.

3. Breeding programme should be initiated to evolve hybrids that are immune, resistant or tolerant to certain diseases particularly root rot and virus diseases.

4. Cultural practices such as inter-cropping, root pruning, mulching, irrigation practices need reorientation and proper standardization for respective citrus zones in India.

5. Nutritional studies (both for macro and micro nutrients) should be planned properly with respect to different soils, rootstocks and scion varieties in order to formulate standard practice of fertilization. Soil and leaf analysis technique must be made popular with the growers as a guide in recommending their manurial schedules.

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ITEM NO.~~3(i)~~: 4(iii)

INTENSIVE AREA PROGRAMME FOR ORANGES :

GENERAL :

Citrus fruits fall into three groups, viz., (i) Oranges, mandarins, tangerines, clementines and satsuma types; (ii) lemons and limes; and (iii) grape fruits. The first group contributes 80% of the total world citrus output and the other two making up the remainder in roughly equal proportions. India has about 1,05,396 hectares under citrus and production is of the order of 10.12 million tonnes. It accounts for more than 1[illegible] of the total fruit production in the country. In 1961, of the total production of different fruits belonging to the citrus family, the share of sweet orange i.e., Mosambi, Malta, Sathugudi and Batavian was 23%, Mandarins ie., Nagpur santra, Assam santra, Coorg santra, and Sikkim santra etc. 39%, Limes 2[illegible]% and Lemons 5.34%. The position does not appear to have materially changed in recent years. Production of sweet oranges is concentrated in Andhra Pradesh, Maharashtra, Punjab, and Rajasthan. Mosambi is the major crop in [illegible] Maharashtra and Rajasthan while Sathugudi and Batavian are more important in Andhra Pradesh. Punjab accounted for about 83% of the area under Malta. Cultivation of mandarin oranges is concentrated in Maharashtra (Nagpur santra), Mysore (Coorg oranges) and Assam (Khasi oranges). Madhya Pradesh, Punjab Kerala and Tripura are also among the states having more than 1000 hectares under mandarin oranges. Andhra Pradesh and Uttar Pradesh contributed 39.59% and 13.22% respectively of the area under lime in the country (28373 hectares). Of 5663 hectares under lemon in 1961-62 about 38% of the area was in Assam, 25.7% in Bihar and 16% in West Bengal.

Almost the entire production in Citrus fruits is consumed within the country. Inspite of this, the per capita consumption in 1961-62 was only 2.53 kg. as against 55 kg. in Israel, 45 kg in Lebnon, 36 kg in U.S.A. 24 kg. in Spain, 19 kg. in Italy, 30 kg in Canada, 13.6 kg in U.K. and 18 kg in Australia.

WORLD POSITION :

The principal producers of oranges and tangerines include U.S.A., Brazil, Japan, Italy, India, and Israel. Lemon and limes are mainly grown in U.S.A., Italy, India, Greece, Spain and Turkey. Grape fruit production is concentrated in U.S.A., Israel, Argentina, South Africa, Cypress and Jamaica. Of the total production of 21.3 million tonnes in 1966, 4.4 million tonnes entered the World trade ie., 3.5 million tonnes of oranges, 0.6 million tonnes of lemons and limes and 0.3 million tonnes of other citrus fruits. West Germany, France and U.K. accounted for 30%, 26% and 15% of citrus imports into West Europe which absorbed 90% of the citrus imports. Europe secures supply of citrus fruits from mediterranian countries during winter and South Africa. Brazil and U.S.A. during summer. Outside Europe major importing countries include Singapore, Malaysia and Hongkong.

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In countries like U.S.A., Greece, Portugal, Argentina and Brazil over 80% of the crop is consumed locally while domestic utilisation in Italy, Spain, Morocco, Israel, Cypress and Lebanon is much less than 50% due to the export oriented nature of their industry.

Intensive Area Programme for Orange Production :

So much for the background information. In what follows it is proposed to briefly disucss the strategy for future development of orange cultivation in the country. The major objective of the development programme will be to increase production for internal consumption as well as for export. Export possibilities are more pronounced in the case of oranges and need to be exploited fully.

In view of the heavy incidence of die back disease orange production is facing a crisis and the immediate problem is to conserve whatever is already available before thinking about expansion. While this may be the immediate short term necessity it will not be possible to ignore the long term aspect relating to raising productivity, since orange is a long gestation crop. Hence the focus has to be both on conservation and expansion

The average yield of mandarin oranges per hectare in India is estimated at 10.84 tonnes and that of sweet oranges 11.42 tonnes. The yield of mandarins in Mysore was reported to be 14 tonnes. The average yield of seedless Satsuma variety of mandarins developed in Japan was reported to be 20 tonnes. Isreael was reported to be raising 16 tonnes of Shamouti oranges. The yield of Washington Navel was 30 tonnes in Spain (42 kg per tree). In Italy average yield per hectare ranged from 15 tonnes of mandarins to 16 tonnes of sweet oranges. In Greece the average yield of orange was 20 tonnes and Morocco 15 tonnes (some modernised groves give 30 tonnes). Early Navel, Valencia late and Shamouti are among the well known international varieties.

A comprehensive and intengrated area programme covering upgrading of existing groves, planting new groves, introduction of new varities, production of nursery stocks with suitable root stocks and grafting material should be implemented on priority basis for stepping up production of oranges in the near future. This programme should aim at covering atleast 10000 hectares distributed as 4000 hectares for mandarins and 4000 hectares for sweet oranges. Out of these 10,000 hectares it should be the aim to bring atleast 2000 hectares under varieties like Early Navel, Valencia, Shamouti, Satsuma, etc. This will enable us to reach a level of 20,000 tonnes of export during the next 10 years. If conditions are favourable, it will be worthwhile covering larger areas. With our local varieties we cannot complete in a big way in foreign markets. Besides lower productivity our varities do not compare favourably with the internationally known varieties in regard to colour, juice percentage and seeds content. In the immediate future there is however scope for exporting our mandarins and sweet oranges to Singapore, Malaysia and Hong-kong and this should be fully exploited.

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The area to be covered in different States may be roughly as follows :-

	Sweet oranges.	Mandarins
Andhra Pradesh	2200	---
Assam	-	700
Maharashtra	1600	1500
Punjab	1500	200
Rajasthan	400	-
Mysore	-	1300
Tamilnadu	-	100
Kerala	-	200

The acreage to be brought under exportable varities should be decided after a regular survey of suitable areas.

In many coffee estates orange trees have been raised as shade trees. Production of oranges has, however, not been given much attention and the planting material used is also not of very good quality. Grafted plants are not also available on a large scale and the planters generally raise trees from seedlings. It will be possible to achieve immediate gains if concentrated efforts are made to improve the trees in the coffee plantations since the enlightened planters will be very receptive to modern and scientific technique and have the necessary resources and organisation to carry out comprehensive schemes meant to increase production of oranges.

In each of the states covered by the Area programme a good progeny orchard should be developed for producing certified planting material. The results of the research achieved in the Gonicoppal station in Mysore State regarding root stocks should be followed. The bud wood has to be obtained from the elite trees identified within the State to be supplemented by whatever quantities that could made available by reputed research stations and nursuries outside the State.

Production of grafts of exportable varieties should be a major item of work in the nursuries. Arrangements should be made to procure necessary bud wood through FAO and other international agencies. The material available in our experimental stations and other orchards in the country should be fully utilised. It is reported that Satsuma variety of mandarin has been successfully grown in Coorg and there are about 71 fruit bearing trees besides a number of young plants.

The implementation of the programme on a selective and intensive basis should be entrusted to special staff. The staff to be sanctioned may include one State level officer and a team of one Horticultural Assistant, One Plant Protection Assistant and five to ten fieldmen for a unit of 1500 hectares. The yardstick should be flexible since more fieldmen may be needed when the area is dispersed while a larger area can be covered with lesser staff if the plantations are contiguous and concentrated. Provision may be made for

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/subsidy on demonstrations, / grafts and pesticides. It may also be necessary to subsidise interest on loans taken by smaller cultivators to raise new orchards since they may have to wait for more than 5 years before realising regular income.

Special arrangements will be necessary to meet the credit requirements of the programme. It will take 7 years before the gardens start yielding a normal crop and for the first 5 years there may not be any income except in areas where there are possibilities of intercropping. Under these circumstances the market value of land offerred as security will be much less than the potential value after full development of the orchards. Unless the banks take into account of the potential value for the purpose of calculating the security requirement for term loans, most of the cultivators will be deprived of adequate credit facilities.

In each of the project areas, special schemes covering a few villages with phased targets should be prepared and submitted to the banks for general approval and allottment of an over all credit limit. It should be the duty of the special staff sanctioned under the scheme to identify suitable areas, prepare individual production plans and closely follow up the utilisation of the credit.

A provision of Rs. 1 crores may be made in the Fifth Five Year Plan for the special programme for increasing production of oranges. 50% of this amount may be earmarked by giving long term loans for raising exotic varieties; of oranges for export. It will also be necessar to provide for processing units in the areas selected for intensive development. These units may be organised in the Cooperative sector.

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Item No. 13 (11)

ALL INDIA SEMINAR ON CITRICULTURE
NAGPUR - 1972

CONTROL OF KANS (SACHHARUM SPONTANEUM LINN) WITH BROMACIL HERBICIDE IN YOUNG MANDARIN ORANGE - SOME - PRELIMINARY OBSERVATIONS

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Kans (Sachharum Spontaneum Linn)is a perennial grass belonging to gramineae family. Because of its underground roots and rhizomes it is very difficult to eradicate with usual method of weed control i.e. hoeing or hand weeding. The underground rhizomes remain dormant in dry season and sprout with commencement of rains. This weeds propagates both from seed and vegetative parts. Its underground rhizomes form dense mat which is difficult to eradicate with common plow. Deep plowing with tractor or digging with manual labour is the only wat to check this seed menace.

The problem of eradication of this weed becomes still more difficult in irrigated areas. The thick mat of this weed spreads extensively throughout the area in an irrigated section of the field. The eradication of kans is a problem with young santra orchards. The continuous ervasion of this grass makes it difficult for the young plants to establish. Inspite of the heavy plowing and picking of underground rhizomes of kans before setting the yound santra plant the multiplication of this weed continues. The young plants requires frequent irrigation and the extension of the patches of kans is ever on increase. Kans, thus, becomes a serious problem with growers as it competes with the young plantation of santra. This aggressive weed competer with santra for water, nutrient and ultimately the young santra plant remains stunted with poor growth and the area round about is infested with kans unless it is checked. The usual method of eradication does not work in young orchards. The deep digging for removal of underground rhizomes will injure the rootlets and fibrous roots of santra budgraft. Thus deep plowing or digging is impracti-

cable in young mandarin orchard.

The new herbicide bromacil (Hyvar X) belonging to a group of chemicals known as uracils has been reported to control a large number of annual weeds and a number of perennial grasses. The usual contact herbicides like (Grammoxone (Paraquat) has no effective control over this perennial grass weed like kans. It kills only the above ground portion and requires frequent spraying. This new herbicide i.e. bromacil is reported to attack the plant through the root system. In U.S.A. bromacil has been approved for spot treatment of small patches of perrennial weeds like bermuda grass saltgrass, Johanson grass etc.

A preliminary trial was therefore undertaken at a Regional Fruit Research Station, Katol to control the spots of kans in young santra orchard in the month of July 1970. The two year old the santra budgeraft were budded on rough lemon roots. The effectiveness of this herbicide it reported on soils with organic matter or clayey soils. The use of this herbicide is excluded in sandy and sandy loam soils. (Day et al 1966). The soils at Regional Fruit Research Station, Katol are clayey therefore this herbicide could be safely used for spot treatment. The thick spots of kans were located between and around the young santra plants.

The spot treatment of bromacil was given at the rate of 5 Kgs/acre in the month of July, 1970. The thick spots of kans in the orchard were first located and demarked. The spots were first scrapped clean of kans and soil exposed for spray application. The spraying of spots was done with Knap sack sprayer with flood-jet, flat, fantype hozzle, 20 litres of this solution per 1000 sq. ft. area was used. Immediately after the spray the spots were water sprinkled with water cans followed by very light surface irrigation. While spraying care was taken not to allow to drift the solution on budgrafts.

The effect of spot application of bromacil was visible within two weeks after spray. In the beginning the healthy green colour of the leaf-blades was disappearing and tips of the leaf blades were seen drying. After a month after spray ground portion of the grass was completely dry and weedless patches were observed. The effect remained 5 months after spray treatment and further effect is under observation. It was also observed that the Lavala (Cynadone dactylon) and Hariali (Cyperus rotundus), Hiran Khuri (Convolvulus arvensis), were controlled with bramocil.

Some minor toxic symptoms on the young santra plants were noticed. The symptoms observed were yellowing of main veins and veinlets, of leaves. In week plants slight die-back of the or two twigs was noticed. This effect was persistant two to four months after spray. But this toxic effect was observed in hardly one or two plants in the whole of the orchard.

These preliminary observations provide us reasonable assurance about the effective control of kans in young non-bearing santra orchard with clay or clayey loam soils.

The cost of herbicide is the most important economic consideration for its use. The comparative cost data has been collected. The usual method of kans control in young santra orchard is pulling of kans shoots with hand in rainy season. It is claimed that it is easier to pul out the kans in wet soil in rainy season. But this is most laborious method and many times the underground rhizomes remain in the soil and does not give effective control. Digging the thickly infested areas with manurial labour is another method of eradication. The local rate of digging kans per 1000 sq. ft. is Rs.25/-. The cost of 100 grams bromacil required for 1000 sq. ft. area works out to be Rs.18.30. Thus as a spot application bromacil appears to be economical and safe as compared to manual labour for control of the kans.

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ABSTRACT

In preliminary trials with the spot treatment, Bromacil (Hyvar x) herbicide, at the rate of 5 kgs./acre for the control of kans (*Sachhrum spontaneim* Linn) in young Santra orchards in heavy soils of santra-growing tract of Nagpur Division, proved effective. The cost of application of this herbicide was comparatively less than the conventional digging method.

Minor toxic effects like yellowing of main-veins and veintets were also noticed in few santra plants.

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13 (iii)

ALL INDIA SEMINAR ON CITRICULTURE
NAGPUR - 1972

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2,4-D SPRAYS IMPROVE THE CROP PRODUCTION IN SWEET ORANGE.

By

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Sweet orange is the major commercial fruit in Andhra Pradesh. The normal fruit set is as high as 75 per cent; yet the average tree yields are low because of the heavy fruit drop during the early period of 3 months after fruit set and again 2 months before harvest ranging from 63 to 83 per cent (Rao, 1969). The fruit set is also affected under adverse climatic conditions. There is a vast scope to improve the yields as the individual trees are found to bear 1000 to 1500 fruits. Randhawa and Dhillon (1965) stated that the plant hormones are responsible not only for the growth of fruits but also their continued attachement to the plant. Sharma and Randhawa (1968) observed that the plant regulators were selective in action on different orange varieties. Therefore trials to increase the fruit set and reduce the fruit drop with several plant growth regulators were initiated at Regional Fruit Research Station, Anantharajupet as early as 1957 and conclusions were arrived at, that 2,4-Dichlorophenoxy acetic acid (2,4-D) at 5 to 10 ppm was effective in increasing the fruit set in certain seasons under unfavourable conditions and at 10 ppm reduced the early fruit drop appreciably and at the same concentrations minimised the pre- harvest fruit drop most effectively and consistently in all the years (Rao and Swamy 1963). Based on these findings, a schedule of 3 sprays with 2,4-D at 10 ppm was evolved and pilot trails on the scale were carried out during the past three years (1968 - 1970) at Pulivendala of Cuddapah District which is famous for citrus production. The results of these experiments are presented in this paper.

...P.T.O.

MATERIALS AND METHODS

The experiments to study the effect of 2,4-D sprays at 10 ppm on yield was initiated in 1968 on Sathgudi variety of sweet orange and repeated during 1969 and 1970 during the main cropping period from February to November. Trees of uniform age and size were selected. The details of the trails are tabulated below.

Details	Ist trial (1969)	2nd trial (1969)	3rd trial (1970)
1. Design	AB BA	AB BA	Randomised Block
2. Replications	10	10	6
3. Treatments	2	2	4
4. No. of trees per plot	3	2	1
5. Dates of spraying			
i) at flower stage	19.2.68	6.3.69	16.3.70
ii) after fruit set	1.4.68	25.3.69	30.3.70
iii) before harvest	11.9.68	7.10.69	13.10.70
6. Date of harvest	21.12.68	4.12.69	22.11.70
7. No. of fruits in each treatment analysed for physico-chemical characteristics.	10	10	3

In the first and second trials, a schedule of three sprays of 2,4-D was given on the dates mentioned above and the performance of trees was compared with that of unsprayed trees. In the third trial, the effect of the schedule of three sprays against two sprays at flowering and after fruit set and a single spray at flowering alone was studies.

Preparation of spray solution:-

Pure 2,4-D chemical was dissolved in minimum quantity of 95% ethyl alcohol and thereafter diluted with the required water to prepare the desired concentration. The wetting agent 'Sandovit' was added to the spray solution at 0.001 per cent.

The spraying operation was attended on clear sunny days, with a rocker sprayer so that each tree received uniform quantity of 14 litres of spray fluid.

P.T.O.

R E S U L T

In the first experiment, after the trees were sprayed at full bloom, the second and third sprays were supplied 41 days and 200 days later whereas in the next experiment, they were done 19 days and 210 days later respectively. The data recorded at the time of harvest are furnished in Table - I.

T A B L E - I

Showing the effoect of 3 sprays of 2,4-D on crop yield of sweet orange.

Treatments	Mean tree yield in number of fruits	
	1968	1969
Sprayed thrice	748.4	341.4
Control (No spray)	545.9	258.4
Calculated 't'	5.75	4.471
Observed 't' @ 1%	3.252	3.258

The schedule of three sprays was consistently effective in both the years in increasing the yield of trees significantly over unsprayed trees by 37.1 per cent in the first year and by 32.1. per cent in the second year.

In the third year of experimentation, the second and third sprays were given 15 days and 207 days after the first spray. The harvest data are furnished in table - II.

TABLE-II

Showing the tree yields ~~are influenced~~ by the number of 2,4-D sprays

S.No.	Treatment	Mean tree yield in number of fruits.
1.	Single spray	319.0
2.	Two sprays	335.5
3.	Three sprays	379.5
4.	Control (No sprays)	295.5
5.	C.D. at 5%	57.6

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To secure the maximum yield three sprays were found essential, which improved significantly by 28.4 per cent over control and 19% over the single spray. Although the differences between the signle and double sprays and the control were not significant, a gradual increase in crop yields was observed as the number of sprays increased.

Thus in all the three trials, the schedule of three sprays proved most effective in stepping up the crop production by 28 to 37 per cent.

TABLE - III

Effect of 2,4-D sprays on physico-chemical analysis of sweet orange fruits -

Fruit character	Mean value for fruits in the different treatments (No. of sprays) 1968		1969		1970			
	3 sprays	control.	3 sprays.	Control.	3 sprays	2sprays	1 spray	Control.
Fruit weight(g)	278.5	270.3	212.9	211.2	227.0	214.0	198.0	211.0
Juice (%)	30.5	31.04	31.6	31.4	31.8	31.6	31.4	31.5
Brix (o)	8.07	7.49	7.77	8.5	8.0	8.5	8.5	8.0
Acidity(%)	0.532	0.543	0.719	0.713	0.728	0.718	0.712	0.7[illegible]
Brix/acid	15.16	14.35	10.9	10.9	11.7	11.3	11.9	11.1
Reducing sugars(%)	-	-	-	-	2.60	2.24	2.19	2.5[illegible]
Total sugars(%)	-	-	-	-	3.65	3.36	3.04	3.2[illegible]
Seed content (No.)	19.5	18.8	4.0	7.3	8.0	8.0	6.5	10.0

The average fruit weight showed a definite increase during the first and third years from 3 to 7.6% The increase in juice content was negligible. The brix value improved from 6.3 to 7.8 % and brix-acid ratio by

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5.4 to 5.6 per cent. The acidity was reduced by 2.9 per cent in the first year and increase very slightly as a fraction, in the subsequent years. The fruits treated with 3 sprayings developed bright orange yellow colour and were very attractive.

The seed content reduced appreciably in the last two trials by 20 to 45 per cent. The fruits were analysed for reducing sugars and total sugars in the last season only and found to have increase by 4.4. and 11.6 per cent respectively.

DISCUSSION

The period of fruit development and maturity is 9 months in respect of Sathgudi variety which is largely grown in the state. The main flowering season is February and March and harvests are done from November to December when the fruits develop orange yellow colour. Therefore, to achieve the object of improving the final yeilds at regular harvest period, it is necessary to spray the growth regulator repeatedly at different periods of fruit development as the effect of the chemical lasts only for a few months, as reported by Sharma and Randhawa (1968 b) that a single spray at full bloom had no effect in reducing preharvest fruit drop. Even the single spray and double sprays produced beneficial results but comparatively lesser than the three sprays proving the above statement. The observations indicated that the sprayings to reduce early drop and preharvest fruit drop were more essential than the spray at flowering only.

The timing of sprays is found most important as also observed by Sharma and Randhawa (1967) in Hamlin and velencia Late varieties of sweet orange. The maximum percentage increase in yield was observed in the first trials when the second was given 41 days after fruit set and 100 days before harvest. In the second and last trials the second sprrying was done after 19 and 15 days after the 1st spray but the third one was given 63 days and 39 days before harvest respectively. As such the percentage increase in yield was appreciable in the second experiment when compared with the latter, indicating the importance of the timing of the third spray to control the preharvest fruit drop. Since Rao and Subba Rao (1962) found that two sprays, one month and two months before harvest reduced the pre-harvest drop further than a single spray, it may be useful to include four sprays in the schedule as evidenced in these experiments.

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In all the trials the size of the fruit was appreciably influenced by 2,4-D sprays and in accordance with the findings of Randhawa and Dhuria (1965) in sweet lime, Sharma and Randhawa (1968) with Jaffa oranges. The juice content and chemical constituents were not effected by these sprays as the figures for these were either not consistent or small.

The results are conclusive and the schedule of three sprays at flowering, 15 to 30 days after and 200 days after fruit set can be recommended as a regular horticultural practice. One more spray will be beneficial if given 230 days after the flowering. The chemical can also be mixed in the compatible insecticidal spray solution at 10 ppm concentration and sprayed to avoid extra expenditure. Such sprays also showed beneficial results during 1967.

S U M M A R Y

1). Based on the previous findings, a schedule of 3 sprays of 2,4-D 10 ppm at flowering, during early period of fruit development and before harvest was evolved and tested for its efficacy in increasing the final yields at harvest.

2). The trees sprayed thrice produced singinificantly higher yields than unsprayed ones consistently. This schedule was found more effective than either a single spray at full bloom alone or with another spraying 15 days after the fruit one.

3). The fruit weight improved appreciably although the physico-chemical characteristics were not influenced.

A C K N O W L E D G E M E N T S

Since thanks are due to Dr. S.N. Rao, at present Principal Incharge, Agricultural College, Bapatla who pioneered the work on application of growth regulators on horticultural crops at this station and offered guidance in conducting the pilot trials. Acknowledgements are due to Andhra Pradesh Agricultural University for providing the necessary facilities in this regard.

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A B S T R A C T

After conducting several trials, 2,4-Dichlorophenoxyachetic acid 10 ppm was determined as most effective in increasing the fruit set and reducing the fruit drop in Sathgudi sweet orange. The effect of schedule of three sprays at flowering, after fruit set and before harvest was studied in pilot trials during the past three years. The final yield was significantly increased by 23 to 31 per cent over control. In the third year it was compared with one spray at flowering and a repeated spray after fruit set. A gradual increase in yields was observed as the number of sprays increased. The third spray 100 days before harvest was found beneficial. The size of fruit showed perceptible increase due to 2,4-D treatment while the chemical constituents were least affected.

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Item No. 4 (vi)

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PROBLEMS & PROSPECTS OF MANDARIN (*Citrus reticulata* Blanco) IN MYSORE STATE.

by

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Citrus acreage in India is declining every year due to citrus 'die back'. Several workers (1,2,3) having reviewed the work done on Mandarin in India have suggested various steps to combat this complext malady which ravages some of our most productive citrus growing centres. There are two well established Citrus Research Stations at Gonikoppal and Chethalli in Mysore State where considerable amount of research work covering root studies, root stock trials, fertilizer requirements of mandarins based on root and foliar analysis, standardization of shading, irrigation and cultural practices were carried out. Inspite of this citrus decline takes heavy toll year after year. With this background under the leadership of Dr. K.C. Naik, Vice Chancellor of University of Agricultural Sciences, Bangalore several meetings of South Indian Horticultural Research workers were convened during 1970 to evaluate the present status of citrus decline in Southerin States of India and to evolve a new line of approach to tackle this problem. It was generally felt in these meetings that the isolation of superior high yielding clones of citrus was urgently needed to improve the citrus Industry of South India. Since the Mysore State has the largest acreage under mandarin, research workers of University of Agricultural Sciences, Bangalore were requested to take up leadership in the Mandarin improvement programme.

PRESENT STATUS OF MANDARIN DECLINE PROBLEM IN THE MYSORE STATE:

In Mysore State, out of the 50,000 acres under citrus more than 80 per cent is under mandarin distributed mainly in Coorg, Hassan and Chikmagalur Districts. Extensive field surveys were undertaken during November - December 1970 and July 1971 to identify the specific causes responsible for decline as well as to locate superior high yielding old mandarin trees.

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In Mysore State Mandarins are grown in humid subtropical zone of Western Ghats at an elevation of 600 - 900 M. M.S.L. where 80 per cent of it are interplanted with either arabica or robusta coffee. Major area is under seedling mandarin trees. Since planters are well versed with the coffee cultivation and have less problem with coffede marketing they prefer coffee as a main crop and treat mandarin trees as a subsidiary or mixed crop. Planters generally yet very low price for the mandarin because they sell the standing crop on contract basis to the middlemen who handle both harvesting and markctting. This is partly because the main harvesting season of mandarin coincides with the coffee harvesting season.

The mandarin crop is raised as a rainfed crop and the two main harvesting seasons are June-July (Monsoon crop) and November-December (Summer crop). Generally most growers are at the mercy of nature for the blossom showers. However wherever sprinkler irrigation is practiced to force early flowering, growers got early heavy crop. In Coorg, mostly summer crop was taken and all monsoon fruits were removed when they are young. The monsoon fruits in generaly have very low total soluble solids and are insipid in taste. Inspite of this, large portion of total annual production of mandarins in Chikmagalur area is from the monsoon crop.

In general, no additional fertilizers are given to mandarin trees interplanted in the coffee estates. Besides no seperate plant protection sprays are given to mandarins. Among the diseases leaf fall and fruit rot caused by Phytophthora palmivora is a serious one and is widespread in all the three districts. If proper control measures are not taken trees will succumb to this disease in three to four years. Powdery mildew is yet an another important disease which is particularly severe in Chikmagalur area. It is prevelent in all three flush periods and in severe cases only black tips remain. Diseases like wither tip, pink disease and diplodia blotch are also present particularly in Coorg plantations. In heavy soils stump rot and root rot are also problems. Among viruses both tristieza and greening are present. However, mandarin seedlings are known to be tolerant for tristieza while greening is a slow progressing disease.

According to planters the decline of old seedlings trees starts only after one or two heavy crop. In almost all such cases niether additional fertilizers are added to such trees nor the fungicidal sprays are given to protect their foliage. Death of these trees seems to be mainly due to poor management practices. In Coorg there are Orchards

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where few above 25 years old seedling trees interplanted with coffee and receiving fertilizers, plant protection sprays, irrigation etc., Here the plants are healthy and yield as high as 1000 fruits per tree. The general conditions of the plants are still better in Chikmagalur area where mandarins are grown under shade and the foliage conditions of the trees are excellent. In fact some orchards in these area where majority of the plants of 20 to 30 years old are free from any symptoms of decline and some of these trees yield as many as 3000 to 6000 fruits. In all such best orchards, particularly in Chikmagalur area, seedlings are raised by the planters themselves from the seeds collected from some good trees. Again in Chikmagalur area while and old seedling trees are free from diseases like pink disease, new seedlings and buildings obtained from outside sources have this disease.

Out of the several root stocks tried at Gonikoppal and Chethalli rough lemon (C.Jambheri), trifoliate orange (Poincirus tri foliate Raf.) Baduvapuli (C. Pennivesiculata Tanaka) troyer citrange Rangapur lime (C.limonia Osbeck) and Belladakithuli (C. mederaspatana Tanaka) seems to perform very well. But budded plants are not popular still with the growers because they are comparatively dwarf and have dense foliage and thus make poor interplants in coffee. However, in two estates at Chikmagalur buddlings of various ages were seen growing as interplants in coffee. In one estate 8 to 10 years old budlings have already started showing the symptoms of decline. It appears that all these buddlings are not on same root stocks since at least four rootstocks were identified from the shoots coming from the stocks. Plants on sweet lime and sour orange are already showing the symptom of decline. Plants on rought lemon are performing very well but are producing more of monsoon oranges.

SUGGESTIONS:

Based on the above observations few suggestions can be made to improve the productive life of the existing mandarin trees.

i) Planters should be advised to apply fertilizers seperately to mandarin plants. To startwith planters can follow the fertilizer recommendations of Chethalli Research Station. i.e. a minimum of 0.7 kg. N,0.45 kg. P205+and 0.7kg. K20 split into 3 doses and applied during three flush periods.

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ii) At least two fungicidal sprays should be given to control *Phytopthora* and Powderymildew. Cock-tail sprays of fungici-des and micro nutrients particularly of zinc and mangenese may help very much in improving the health and productivity of the existing plants.

iii) Where irrigation facilities exist planters should be encouraged to irrigate to force mandarins to flower in summer. Many growers are aware of the above recommendations but very few practices them because of economical reasons. Since the growers in general get very low price from the middlemen they hesitate to invest any money on fertilizers, plant protection chemicals and on irrigation equipments.

iv) The marketing difficulty of mandarins is perhaps one of the most important but least discussed factor which directly or indirectly is responsible for the mandarin decline. Only with assured fair price planters may take more iterest in mandarin cultivation.

v) Labourers engaged by the middlemen cause considerable damage to the plants during harvesting operation. Therefore, good supervision is required at the time of harvest to minimise damages.

A NEW LINE OF APPROACH TO AN OLD PROBLEMS

One of the most interesting fact brought out by the present survey is that even in badly affected plantations there are some sporadic plants which are normal with good tree shape and satisfactory bearing. This pointed out that these trees may have some genetic potentiality to resist the adverse conditions. Since variations does exist in mandarin seedling orchards it offers an excellent opportunity to select good parental material for the future work. Such selections were made with a view to isolate superior high yielding disease tolerant strains of mandarins. The criteria used for selecting a seedling mandarin tree is the field survey are:

a) The tree should be above 20 years old.
b) The tree should posses good shape and good foliage.
c) The tree should be a consistent heavy hielder.
d) Fruits from such trees should be of superior qualit

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During the last, two field surveys in 1970 and 1971 thirty such trees were located in the three districts. The preliminary data regarding the estimated yieldand fruit qualities of the twenty two selected trees are given in Table - I.

It is also observed that in general the fruits in Chikmagalur area are smaller in size with thin rind and are having higher oil content. The number of seeds, the total solids and acid contents vary from region to region with age groups. However, the average number of segments per fruit did not change considerably.

Seedlings from the seeds of such selected trees are ready for transplanting in nursery beds at the Gandhi Krishi Vignana Kendra (G.K.V.K.) Bangalore. These seedlings appear to be free from the prevalent virus diseases. Further, these seedlings will be grown at Bangalore which is far away from the main mandarin growing zone and thus are expected to be free from the common pests and diseases of mandarin. However regular plant protection measures will be adopted? We hope to have a very good nucleus disease free mandarin orchard at Bangalore for future research work.

The field survey work will be continued for four more years, to study the performance of these selected trees and also to make necessary additional selections. Specific crosses of trifoliate orange with the selected trees are contemplated to obtain the nucellar seedlings of the selected plants. Such nucellar seedlings of all the selected trees will be planted at G.K.V.K. Bangalore and Mudigere. In years to come the performance of nucellar seedlings can be evaluated under different agro-climatic conditions. This may help in future to release some promising mandarin clones for general cultivation. Evaluation of these nucellar seedlings under different agro climatic conditions coupled with long range study of selected mother trees may help us to identify the promising superior strains of mandarin suitable for cultivation in the Mysore State.

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TABLE I

Estimated yield and fruit quality attributes of the twenty two selected mandarin trees in 3 districts of Mysore State in the year 1970 -

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Tree No.	District	Estimated age of the tree in yrs.	Estimated yield No. of fruits/tree.	Some characters of fruit quality as Mean values					
				Fruit weight g	Peeled fruit weight g	No. of segments per fruit	No. of seeds per fruit	T.S.S. percent	Acidity percent.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10
*1	Coorg	22	1000	104	73	8	15	10.3	0.91
*2	-do-	22	700	143	103	10	19	11.2	0.91
*3	-do-	22	1000	183	125	10	19	11.1	-
*4	-do-	22	1000	132	92	10	15	11.9	0.85
	Mean		925	141	98	10	17	11.1	0.89
5.	Chikmagalur	22	600	167	122	11	22	12.9	0.70
6.	-do-	22	500	146	105	10	19	11.2	0.81
7.	-do-	22	500	113	82	10	14	9.7	0.44
8.	-do-	22	500	107	85	9	15	12.8	-
	Mean		550	133	99	10	17	11.7	.55

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
9.	Coorg	25	500	134	101	10	18	11.4	0.79
10.	-do-	25	500	150	115	10	21	10.5	0.83
11.	-do-	25	300	193	145	10	18	10.5	0.60
12.	-do-	25	400	174	130	10	20	11.0	0.70
13.	-do-	25	600	166	124	9	21	11.9	0.91
*14.	-do-	25	1500	143	103	11	18	11.1	0.58
*15.	-do-	25	1500	159	117	10	20	9.9	0.62
		Mean	750	160	119	10	20	10.9	0.72
16.	Chikmagalur	25	600	90	63	10	20	11.1	0.60
17.	-do-	25	1500	55	42	9	12	12.5	0.89
		Mean	1050	73	53	10	16	11.8	0.75
18.	Coorg	30	800	168	117	10	21	10.3	0.74
19.	-do-	30	800	169	120	10	19	11.6	0.89
	Mean		800	169	119	10	20	11	0.82

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
20.	Hassan	30	500	140	100	10	18	9.2	0.14
21.	-do-	30	500	156	114	10	20	10.0	0.38
	Mean		500	148	107	10	19	9.6	0.26
*22	Chikmagalur	40	2000	100	68	10	12	10.7	-
	Mean		2000	100	68	10	12	10.7	-
	Overall Mean		939	134	97	10	18	11.0	0.70

* Trees from well maintained plantations

A B S T R A C T

Mandarin occupies more than 80 per cent area under Citrus in Mysore State. In general it is interplanted with Coffee and usually grown on its own root under rain-fed condition. Very little attention is paid regarding plant protection, fertilisation and other cultural practices. The main cause of decline seems to be 'Neglectosis' In addition, several diseases due to fungi, viruses etc. also play their part in hastening the decline.

Recent intensive and extensive survey conducted in the Citrus growing regions of the State has revealed that even in badly effected orchards, there are a stray healthy plants of 25 - 30 years old with good tree shape bearing heavy crop. Several such trees were selected in different regions and seedlings raised in a new locality which is isolated from Citrus plantation. Budlings on proven rootstocks will also be raised. Performance of both budlings and seedlings of such selected clones will be tested in different regions. This line of approach seems to be a logical appraoach to combat the Citrus decline.

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ROLE OF THE TRISTEZA VIRUS IN CITRUS DIE--BACK COMPLEX

By

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Poona - 5

Several species of the genus Citrus Linn. are cultivated in India, while C.macroptera, C.indica, C. latipes, C. Ichengensis and C. assamensis grow wild on the eastern Himalayan ranges. For centuries citrus trees have been propagated in India by seed, by cuttings, by layering and also by budding involving use of various rootstocks.

Though die-back syndrome was known to be associated with citrus in India for many years, experimental evidence of the failure of sweet orange on sour orange rootstock was obtained by Brown for the first time in 1920. Brown was unable to interpret the cause of this failure of sweet oranges on sour roots because we learnt much later that this was brought about by the tristeza virus which was shown to be present in India only in 1958.

Tristeza is spread in orchard from tree to tree by 7 species of aphids. In India 6 of these species - Toxoptera citricida, T. aurantii, Aphis gossypii, A. craccivora, Myzus persicae, and Macrosiphum (Dactinotus) Compositae (Sy.D. jaceae) - have been established as vectors. The virus is transmitted by T.citricida in a non-persistent manner and is not retained by the aphids after moulting. It exists in nature in more than one strains. One mild strain (Tm) affords protection to pre-immunized Kagzi lime seedlings against infection by the severe (Tt) strain.

Tristeza virus is composed of thread-like particles about 2000 mu in length and 10-12 mu in diameter. Similar particles were demonstrated in a few phloem cells of each fibrovascular bundle of infected leaf. The virus is believed to be restricted to phloem tissue only.

Observations on rootstock trials carried out in different regions in the country have shown that most widely used rootstock, Rough lemon (*Citrus jamphiri*), has failed in some areas. This is believed to be due to the fact that different strains of the tristeza virus which are detrimental even to Rough lemon which is accepted as a tolerant rootstock prevail in those regions.

Finally, suggestions have been made for avoiding the tristeza virus in orchards.

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GREENING DISEASE OF CITRUS AND ITS ROLE IN THE DIE-BACK COMPLEX

By

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Die-back disease is one of the most serious problems of the citrus industry in India. The disease has been known to be present for several decades and has caused gradual decline of the industry. One of the major causes of the malady is the greening disease which causes various kinds of discolouration of the leaves followed by defoliation of the young twigs. The investigations conducted on the disease during the recent years are reported in the present paper.

SYMPTOMATOLOGY

The most prominent symptoms of the disease are the yellowing of the midrib or lateral veins of the old mature leaves. The interveinal areas along the veins may also show diffuse yellowing occasionally. Such leaves eventually fall and several auxillary shoots grow from the defoliated twigs. This secondary growth consists of short, upright weak shoots with small leaves showing symptoms similar to those due to zinc or iron deficiency. The veins and veinlets are invariably green with interveinal areas chlorotic or there may be green blotches or circular green spots on yellow background. In early stages of infection the symptoms are usually confined to one or two limbs but ultimately they extend to other branches till the whole tree is involved. Partial recovery or masking of symptoms have been observed during the hot summer months but the symptoms appear again with cooler temperatures in autumn and winter. The severity of the disease depends on variety, climate and the stage at which trees get infected.

CAUSE

The greening disease was first reported to be a virus disease of citrus from South Africa in 1965 (Mc Clean and Oberholzer, 1965). The disease was reported from India in

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1966 (Frazer and Daljit Singh, 1966; Frazer et. al. 1966; Nariani et. al. 1967). Recently, however, the disease has been associated with Mycoplasma (Lafleche and Bove, 1970) and the greening mycoplasma has been cultured on artificial culture medium in the laboratory (Ghosh et.al. 1971). Attempts to reproduce the disease with the mycoplasma culture in the medium are in progress.

TRANSMISSION

The greening disease is bud or graft transmissible. The young budded plants in the nursery get infected through the budwood from the infected mother trees. Thus the disease gets disseminated from one place to other with the nursery plants. In the orchards the spread is caused by the citrus psylla, Diaphorina citri Kuway whichis a very efficient vector of the disease (Capoor et. al. 1967). Studies on the vector relationship (Raychaudhuri et. al. 1969) have shown that even a single psylla is capable of transmitting the greening pathogen. The psylla is not able to transmit the greening disease during the span of its nymphal life but it can pick up the pathogen in nymphal stage and transmit when it is adult. The psylla does not become infective immediately after feeding on the diseased plant but there is a delay in the infective power or the latent period of about 8-12 days after acquisition of the pathogen. Once infective, the psylla can infect the healthy plants after a feeding period of about 4 hours on them. It then continues to spread the greening pathogen throughout its life period. The greening disease has also been found to be transmitted through dodder, Cuscuta reflexa Roxb. in artificial transmission tests. The extent of transmission of the disease by this method in nature is not known.

DISTRIBUTION OF THE DISEASE AND THE VECTOR

An extensive survey was undertaken of the citrus orchards throughout India including the Sikkim State and budwood collected from various places was indexed by bud or wedge grafting on indicator plants under controlled insect-proof conditions in glasshouses for confirmation of the disease pathogen. The indexing revealed that the disease is very widespread and occurs singly or in combination with other viruses such as tristeza and exocortis in almost all the citrus growing areas in Northern, Southern, Western and Eastern India including the Sikkim State (Nariani et al. 1967, 1970, 1971; Nariani and Raychaudhuri,1968). The disease was found to be present in sweet oranges (Mosambi and Malta), Grapefruit, Mandarins, Eureka lemon and Kagzi lime irrespective of the rootstocks used. The psylla is a serious pest of citrus particularly during the spring and early summer in Western and Central India. It was, however, found to be present in most of the citrus growing areas surveyed even though

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in small numbers. The incidence of the psylla is very high during March-June at Delhi. It goes down with the onset of monsoon but the insect reappears although in small numbers during autumn although not to the same extent as in March-June. The incidence of psylla is very low during the winter months.

CONTROL

Since the greening disease has been shown to be associated with mycoplasma like organism, effect of certain tetracycline antibiotics was tested in the glasshouse plants as tetracyclines are known to suppress the symptoms caused by several mycoplasma diseases. It was observed that spraying with achromycin and ledermycin at 500 ppm at weekly intervals for ten weeks suppressed the greening symptoms and recovery of the plants was observed (Nariani _et al_, 1971).

Experiments were also conducted to determine if the greening pathogen could be inactivated in the infective bud-wood by heat treatment. Hot water treatment was therefore attempted. It was observed that treatment of the citrus bud sticks to 40°C and 45°C for five hours and to 50°C for 30 minutes or 55°C for 15 minutes in a waterbath could not inactivate the greening pathogen. Attempts were, therefore, made to make use of hot air by exposing the budsticks by hanging them above the water surface in a closed water bath to hot air. It was observed that heating budwood to 51°C for one hour or 49°C for two hours did not inactivate the greening pathogen but exposing the budwood to 47°C for four hours inactivated the pathogen in five out of eight plants budded with the treated budwood.

As the greening disease is spread through the infective budwood by vegetative propagation the best way of preventing its spread to new plantations would be the use of certified disease free budwood or by use of nucellar virus-free plants. Therefore, long range budwood certification programme on the lines advocated in other citrus growing countries but modified to suit the Indian conditions has been recommended (Nariani and Raychaudhuri, 1971) and it is gratifying to note that I.C.A.R. has already launched such a programme in the country with four centres of supply of certified budwood at Poona in Maharashtra, Tirupati in Andhra Pradesh, Ludhiana in Punjab and Kahikuchi in Assam.

ROLE OF GREENING DISEASE IN DIE-BACK COMPLEX

It has been observed that the greening disease causes defoliation of the infected twigs which are prone to attack by various fungi such as _Colletotrichum gloeosporoides_, _Diplodia natalensis_, _Curvularia tuberculata_ and _Fusarium sp._ causing

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ultimately the die-back syndrome. In artificial inoculation tests greening affected plants have been found to be more susceptible to these fungi than the healthy ones (Raychaudhuri *et al*, 1969 a,b). Further investigations have revealed that there is a difference in the aminoacid content of the greening affected and healthy citrus plants (Goswami *et al*., 1971). This might be one of the factors for the susceptibility of the greening affected plants to the fungi involved.

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ABSTRACT

Greening disease of citrus is responsible for heavy losses to the citrus industry in India. In association with certain fungi it causes the die-back syndrome which has wiped out the citrus cultivation in most of the citrus growing regions in the country. The greening disease is spread in nature through infected budwood and by the vector citrus psylla, Diaphorina citri Kuway. Even a single psylla is capable of transmitting the disease and there is a latent period of 8-12 days in the vector before it can become infective. Once infective, the psylla continues to spread the disease throughout its life period. The pathogen which was considered to be a bud transmissible virus has recently been shown to be a mycoplasma and has been successfully cultured in the laboratory on artificial media. The greening disease has shown a favourable response to certain tetracycline antibiotics. Heating the infected budwood to dry heat at 47°C helped in inactivating the pathogen.

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ALL INDIA SEMINAR ON CITRICULTURE
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ROLE OF FUNGI IN CITRUS DIE-BACK COMPLEX

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Die-back has been attributed for the decline of citrus industry in India. A number of factors are reported to be the cause of this disease. It is widely distributed through-out the citrus growing areas of the country and has taken a heavy toll of citrus industry. Beside other factors, a number of fungi viz., Colletotrichum *gloeosporioides*, *Diplodia natalensis*, *Curvularia tuberculata*, *Fusarium* spp. and *Rhizoctonia* sp. have been reported to be associated with the citrus die-back in India. During our recent survey of different parts of the country, *C. gloeosporioides* was found to be most commonly associated with the die-back of citrus twigs and majority of the diseased samples as well as apparently healthy twigs collected yielded this fungus only on isolation. It has been suggested that the probable cause of citrus die-back in India is to be a virus-fungus complex (Raychaudhuri *et al*., 1969). This paper deal with the role of certain fungi in citrus die-back complex.

Symptoms: As the disease is a greening virus-fungus complex, the foliar symptoms on orchard trees are similar to those for greening disease. The foliar symptoms appear in the form of yellowing of the mid-rib and lateral veins of the mature leaves. The interveinal areas along the veins also show diffuse yellowing and ultimately the whole leaf may sometimes turn yellow. Most or all of such leaves fall with the onset of summer or autumn and the die-back of defoliated twigs commences. Beside, die-back of healthy twigs in citrus orchards is not uncommon. In severe cases the branches may die-back to such an extent that in a few years the tree dies. Following death of diseased portions, there is a development of minute black acervuli- the fruiting bodies of the fungus. Die-back of twigs is frequently seen during rainy season, when moisture content of the

atmosphere is high. The spread of the disease depends on variety, climate and the stage at which trees get infected.

Cause: Various causes like fungi, viruses, deficiencies and soil disorders like water logging and high water table and even nematodes have been attributed to citrus die-back. Vasudeva and Capoor (1958) and Capoor (1963) were the first to report that tristeza virus was involved in the die-back syndrome in Bombay now Maharashtra State. Later Fraser and Daljit Singh (1966), Fraser *et al.*, (1966) and Nariani *et al.*, (1967) have discussed the possibilities of the greening virus being the cause of citrus die-back in India. Raychaudhuri *et al.*, (1969) suggested the probable cause of citrus die-back as virus-fungus complex. Recently, Lefbeche and Bove (1970) as well as Ghosh *et al.*, (1971) reported that the greening is caused by mycoplasma like organisms. Besides, several fungi such as *C.gloeosporioides*, *D.natalensis*, *C.tubereulata*, *Fusarium* spp., and *Rhizoctonia* sp., have been found to be associated with the die-back of citrus (Chaudhuri, 1936; Singh and Singh, 1953; Thind and Rawla, 1961; Mukerjee, 1963; Bhatnagar and Prasad, 1966; Lele *et al.*, 1968). There is no evidence, however, that greening pathogen alone can cause sumptoms of die-back on trees in the field or glashouse grown seedlings. Although fungi alone can infect healthy twigs. Greening pathogen causes yellowing of the foliage but actual wood rotting thereby killing the twigs seems to be caused by various fungi.

Reaction of various citrus stocks:

Reaction of various species and varieties was studied against several fungal pathogens and it was found that different species of citrus, under identical conditions, showed a widely variable response to infection even without the association with the greening pathogen. The inoculation tests carried out in the glasshouse on a number of citrus species and varieties showed a strong indication that only the Kagzi lime was highly susceptible to *C.gloeosporioides*, *D.natalensis*, *C.tuberculata* and *Fusarium* Spp., sweet orange and mandarin behaved susceptible, while Herale, Gabbu chinee, Jambheri, Jatti Khatti, were either resistant or showed slight susceptibility. *Citrus karna* though did not show die-back sumptoms under field conditions, was infected under artificial

inoculation tests in the glasshouse. Lele *et al*., (1968) however, found that Troyer citrange, Sweet lime, Grape fruit and Cleopatra mandarin, were resistant against *C.tuberculata* in artificial tests, whereas, response to susceptibility of Rangpur lime, Dancy tangerine, karna khatta, Jatti khatti, kagzi lime and chakotra was in descending order.

In our studies (Singh *et al*., communicated for publication), we have observed that the response of six isolates of *C.gloeosporioides* varied from species to species and also from variety to variety. As recorded earlier, kagzi lime was found most susceptible to all the six strains of *C.gloeosporioides* which was followed by mandarin and sweet orange. Rangpur lime, Sweet lime, Herale, Gubbu Chinee reacted as resistant, whereas, Watson pummelo, Jambheri, Jatti khatti, Karna khatta, Nasnaran and lemon were found to be tolerant. Similarly Chaudhuri (1936) while studying the resistant of seven species of citrus to *C.gloeosporioides*, with two virulent strains, found that under very moist conditions infection never failed but under comparatively dry conditions some of the plants showed resistance to a certain degree. When different varieties of malta (*C.sinensis*) were similarly tested by him, no resistant variety was found.

Interaction of Certain fungi and greening pathogen:

Preliminary studies carried out by Raychaudhuri *et al*. (1969a) have shown greening affected kagzi lime and sweet orange plants when artificially infected with *C.tuberculata* were more susceptible to the fungus and showed severe die-back than those infected with tristeza virus. Recently intensive studies were carried out with two isolates of *C.gloeosporioides*, *D.natalensis* and *Fusarium* sp. by Singh *et al*., (communicated) and observed that above mentioned fungi were able to produce die-back on both healthy as well as on greening affected plants, but the extent of die-back was more in the greening affected plants. Therefore, it appears that the plants weakened by the infection of greening pathogen are prone to be more attacked by such fungi. It is, however, worth mentioning here that the plants affected with greening alone were unable to produce the die-back symptoms when kept for observations in the glasshouse for a period for two years and a half. Such symptoms were produced only when the plants were inoculated with fungal pathogens associated with the disease.

It was also found that the fungal pathogens alone were able to produce die-back but the severity differed.

Latent Infection: Recent survey carried out through out the country revealed that *C. gloeosporioides*, one of the causes organisms of citrus die-back complex, causes latent infection of apparently healthy twigs in various species and varieties of citrus in India. The latent infection was found mostly confined to the bark region and certain amount of the pathogen penetrated into the wood as well. Axillary buds are also infected in a latent form, and this may be the source of primary inoculum of the pathogen to spread through vegetative propogation to new plants as well as to the new areas. Surface sterilization with 0.1% mercuric chloride solution has no effect on the latent infection. It seems that this fungus can enter the tissues of healthy twigs directly and, therefore, it cannot be considered a weak parasite. (Singh *et al.*, In Press).

Physiological variation in isolates of *C. gloeosporioides*:

Utilization of four carbohydrates, viz., D.glucose, D.fructose, sucrose and starch by nine isolates of *C. gloeosporioides* isolated from diseased twigs of mandarin, sweet orange var. Sathgudi and Mosambi, Kagzi lime and Grapefruit from six different places, was studied chromatographically at our laboratory. All the isolates behaved differently in utilization of four carbohydrates. It was, however, observed that those isolates which were able to utilize all the sugars rapidly, were also found to be more pathogenic than others.

Control: Die-back disease of citrus has been controlled by pruning the diseased twigs and spraying with Bordeaux mixture or other copper fungicide. These fungicides are fairly cheap and also give good results, but their use is disadvantageous because, with repeated applications; accumulations of copper in the soil may reach toxic levels. As it is now known that the mycoplasma like organisms are associated with greening disease, Nariani *et al.*, (1971) tried 500 ppm of three tetracycline compounds viz., Achromycin, Ledermycin and Aueromycin. First two antibiotics gave complete recovery of the sprayed plants from the greening symptoms. However, these antibiotics *in vitro* were unable to check the growth of die-back producing fungi. Owing to

the complex nature of disease and the presence of *C. gloeosporioides* in latent form has further complicated its control. Therefore, a number of fungicides and antibiotics are being evaluated in the laboratory to find out their efficacy against die-back producing fungi. So far 19 organic and systemic fungicides including antibiotics have been evaluated in the laboratory. Preliminary trials have shown that Captan, and Fusariol were effective against all the 4 pathogens, whereas cuman and Lunacol were not able to check the growth of *D. natalensis*. Benlate, a systemic fungicide was effective against *C. gloeosporioides*, *D. natalensis* and *C. tuberculata*. Out of four antibiotics tested none was found to be satisfactory. Further work with fungicides is in progress.

From the studies so far made it can be safely concluded that fungi alone and in association with greening pathogen play an important role in die-back syndrome. However, there are certain questions which are yet to be answered, for example, (i) what is the role of latent infection in the epiphytotic of citrus die-back in India (ii) what are the factors which are necessary for the expression of symptoms (iii) what are the changes brought about in the host after infection of greening pathogen, which makes plants more susceptible to fungal infection.

Phytophthora Foot Rot or Gummosis of Citrus:

This disease is widely distributed throughout the citrus growing areas of the world. Of three species of *Phytophthora* reported to attack the citrus trees two, that is, *P. parasitica* Dast. and *P. palmivora* Bull. are reported to be present in India while the presence of *P. citrophthora* (Sm. and Sm.) Leonian is doubtful. The disease is severe under heavy soil, humid atmosphere and shady places. It is a separate disease in itself.

Symptoms: Infection generally starts from the soil surface region of the bark. First lesions appear as a water-soak spot on the bark of the trunk at the bud union or at crown in seedling trees. In the beginning these spots affect thin layers of the bark but later extending through the cambium into the wood. Gum exudation from the affected parts is the main symptom. Gum oozing is conspicuous during dry weather whereas during rainy period gum get dissolved in water and washed away and not observed. The decayed bark becomes shrunken and cracked, shredding in lengthwise as

it dries. Underground portions if affected are not seen. The lesion may encircle the tree trunk in severe cases, causing the tree to die-upward. Spread is generally limited 1-2 ft from the ground. Roots also get affected and further be attacked by secondary organisms which results in the poor growth and decline of the tree. Foliage symptoms show yellowing of the leaves. The leaves of successive flushes are smaller, and twigs, branches and finally limbs succumb. Fruit size becomes smaller in late stages of decline. Footrot can be differentiated from the root rot in that the tree often dies irregularly, one side failing while the other still sound. In severe form, the tree may die within one year of the symptom appearance whereas in others there may be recovery.

Leaf fall and fruit rot are caused by P. palmivora Butl. and severe damage occur in humid areas of Kerala and Mysore States. It is severe on Coorg mandarin during rainy months of June to September. First water soaked lesions appear on the leaves which extend rapidly under favourable weather conditions, ultimately resulting in leaf-fall especially from lower branches. The affected fruits rot, showing a white dowing growth of the fungus and finally such fruits fall-off. Rotting of fruits emit a characteristic Odour.

Cool air, low temperature and abundant atmospheric and soil moisture are the predisposing factors of the disease. A temperature of 80-85^{o}F if best for the growth of P.palmivora (Uppal & Kamat, 1936). pH of the soil is known to influence the growth of Phytophthora. Large number of root infection occur at pH 5.4 to 7.5, mederate infection at pH 4.8 to 6.0 only slight infection at pH 4.3 to 4.5. Deep planting where bud union is below the soil level is responsible for the spread of the disease.

Species of citrus shown variation in resistance to gummosis under field conditions. Mosambi and Pummelo are very susceptible. Mandarin and C.nobilis var. delicosa are somewhat resistant as the extent of lesion is limited and formation of a callus tissue along the edges of the dead bark. Jamberi (C.limonia) is almost immune as there is limited progress of disease and a rapid callus formation with healing of the wound.

Control: Use of resistant root stock is the best means to control foot rot or gummosis. Sour orange, Cleopatra mandarin, Trifoliate orange and Jambheri are the resistant root stocks. As sour orange is susceptible to tristeza and trifoliate to exocortis, only rough lemon (Jambheri) and Cleopatra mandarin may be recommended.

Trees should be budded sufficiently high to prevent susceptible trunks of scion coming in contact with soil.

Planting of citrus should be done in well drained soils and water should not be allowed to stand in the rainy season. Irrigation should not be given as flooding the plots.

When lesions occur at or above the bud-union, the diseased bark should be removed along with half an inch of healthy bark. Exposed areas should be treated with disinfectants followed by application of wound dressing with a fungicide.

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ABSTRACT

Die-back is widely distributed throughout the citrus growing areas of the country and a number of factors including fungi have been associated with the disease; but Raychaudhuri _et al_.(1969) suggested that the probable cause of die-back in India to be a greening virus-fungus complex. Recently, greening virus has been reported to be a mycoplasma like organism. Amongst several fungi reported so far, _colletotrichum gloeosporioides_ Penz was found to be mostly associated with the die-back of citrus. It was also found to be present in latent form in apparently healthy twigs of citrus. Reaction of various citrus stocks studied against several pathogens showed a widely variable response to infection even without the association with the greening pathogen. Kagzi lime was highly susceptible to all the pathogens associated with die-back. Karna Khatta though did not show die-back symptoms under field conditions, was infected under artificial inoculation tests. The pathogenicity of various isolates of _C. gloeosporioides_, isolated from different _citrus_ species, varied from species to species and also from variety to variety. In interaction studies it was observed that the plants affected with greening pathogen alone were unable to produce die-back symptoms, whereas the fungi are able to produce die-back on both healthy as well as on greening affected plants. However, the extent of die-back differed. It appears that greening affected plants are more attacked by die-back producing fungi. Studies on physiological variation in isolates of _C. gloeosporioides_ revealed that those isolates were more pathogenic which were able to utilize all the sugars rapidly. Nineteen organic and systemic fungicides including antibiotics have been evaluated _in vitro_ to find out their efficacy against die-back producing fungi. Benlate, Lonacol Cuman and Fusariol have given promising results, whereas out of 4 antibiotics tested none was found to be satisfactory.

Information is lacking on the role of _Phytophthora_ which causes foot rot or gummosis as well leaf fall of citrus in certain areas of the country in the citrus die-back complex.

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ROLE OF VECTORS IN CITRUS VIRUSES WITH PARTICULAR REFERENCE TO CITRUS PSYLLA IN THE GREENING 'VIRUS'

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Citrus decline has resulted in a serious setback to the citrus industry in the recent years. Many factors are responsible (Chadha et al., 1970). Diseases of virus and mycoplasma etiology are very important among these factors. In Argentina and Brazil alone, about 20 million trees were lost to tristeza during 1930-50. In India, the virus diseases reported so far are tristeza (Quick Decline), zyloporosis (Cachexia), exocortis (Scaly Butt), psorosis (California Scaly Bark), fovoid disease, woody gall (Vein Enation) and greening. All except the last one are caused by viruses. Greening is now considered to be caused by a mycoplasma-like agent. All the diseases are spread through the propagation material. Tristeza, woody gall and greening are transmitted by insects.

The quick decline or tristeza virus that played havoc with the citrus industry of Argentina, Brazil and California has been shown to be present in Maharashtra (Vasudeva and Capoor, 1958; Nagpal, 1959), Andhra (Reddy and Paparao, 1960 a), Delhi (Nariani et al., 1965) and in the Punjab (Anonymous, 1965). _Toxoptera citricida_ has proved to be a very efficient vector of this virus (Hughes and Lister, 1949). _Myzus persicae_ sulz. is also a vector (Vasudeva et al., 1959), as are also the cotton aphid, _Aphis gossypii_ Glover, the groundnut aphid, _Aphis craccivora_ (Koch), and the safflower aphid, _Dactynotus jaceae_ (L.) (Varma et al., 1960; Varma et al., 1965). These aphids are capable of transmitting the tristeza virus even though they may not be able to feed and breed on citrus for prolonged periods. This is so because the virus is stylet-borne and can be acquired by aphids from a diseased plant in a few testing probes and can be readily transmitted to a healthy plant during similar probes without requiring an incubation period. Thus, this virus may be transmitted by migrating aphids without prolonged feeding on citrus, the insects acting as flying needles.

Aphids breeding on citrus can be easily controlled. Sethi and Jawanda (1965) reported BHC 0.25%, menazon 0.2%, nicotine sulphate 0.05%, parathion 0.03% and malathion 0.03% to be effective for their control. Some other insecticides like phosphamidon 0.025% solution, methyl demeton 0.025%, methyl parathion 0.025% or dimethoate 0.025% emulsion should also prove very effective. However, in our arsenal we do not have either a strong repellant which may repel effectively the migrating aphids from settling on citrus trees, or an insecticide with an extremely quick knock-down action to kill aphids in a few seconds while at the same time having long residual action. Thus, there is nothing available at present to prevent migrating aphids from spreading tristeza virus. As spread of tristeza virus cannot be effectively checked through insecticidal sprays, the solution of this problem lies in tolerant rootstock-scion combinations.

The woody gall is also transmitted by aphids, namely Toxoptera citricida, Aphis gossypii and Myzus persicae (Chadha et al., 1970).

Fraser and Daljit Singh (1966) and Fraser (1967) concluded that die-back of citrus in India was mainly due to greening 'virus'. Diaphorina citri, the citrus psylla was suspected as the vector of greening (Bindra, 1966) and recent work (Bindra and Chhabra, 1967: Capoor et. al., 1967) has confirmed this. Citrus psylla is long lived, the adult longevity being 6 months; females have high fecundity of 800 eggs per female; there are 18 overlapping generations in a year and in the Punjab all stages occur throughout the year except during December-January when only adults are found. Further, it attacks all species and varieties of citrus.

Besides, both nymphs and adults suck the plant sap and infect toxin with its saliva, causing drying up of growing shoots tip downwards (Hussain and Dina Nath, 1927; Bindra and Joginder Singh, 1969).

Studies carried out on insect-pathogen relationship have shown that 40-95 viruliferous adult citrus psylla per test plant given a test feeding of 12-15 days transmitted the greening pathogen in 40-83 per cent of the treated plants of sweet oranges, grape-fruit, acid lime and mandarin (Capoor et al, 1967). The work of Capoor (L.C. Knorr in Chadha et al., 1970, p. 84) indicate that a single viruliferous psylla can transmit the pathogen and remain in effective for 76 days. Besides corroborating Capoor's findings, Nariani (1971) has added that citrus psylla can even pick up the pathogen in nymphal stage but transmits only in the adult, stage, and remains ineffective for the whole of its life. Work done in the Punjab

Agricultural University during 1967 to 1969 in which 70 viruliferous adults of citrus psylla per plant were given a test feeding of 50-55 days on Marsh Grape-fruit, Murcot, Troyer Citrange, Trifoliata, Pine-apple, Dancy Tangerine, Orlando Tangelo, Sour-orange, Key-lime, Sweet-lime and Malta Orange, the symptoms appeared first in Marsh Grape-fruit plants 73 days after inoculation. The cumulative number of plants showing symptoms was 6 in Marsh grape-fruit, 3 in DancyTangerine and 4 in Murcot on 8.5.1969, but the number was reduced to 1, 1 and 4, respectively by 23.5.1969. The remaining plants remained symptomless throughout the period of this study indicating that; (i) the pathogen is heat-labile; (ii) the citrus psylla is not an efficient vector under North Indian conditions; and (iii) the remaining varieties may be either resistant or symptomless carriers. Further work is in progress.

In another experiment on varietal differences in tolerance to greening in Pine-apple, Blood-red, Mosambi, Hamlyn and Valencia-late budded on Jatti Khatti, 400 viruliferous citrus psylla per plant in eight lots of 50 each at weekly intervals were confined on 10 plants of each variety with the help of muslin sleeves, while keeping the other similarly caged 10 plants of each variety as control. Symptoms of greening appeared only in 5 of the 10 treated plants of Valencia-late. One untreated plant of Hamlyn variety also showed symptoms. This might be due to infection from the scion or the root-stock. On the basis of the growth and absence of symptoms, Pine-apple and Blood-red are equally good, and better than Mosambi which is better than Hamlyn. Valencia-late is the poorest.

Control of 'greening' involves either eradication of both the inoculum and vector, or the use of resistant/tolerant varieties. Rigorous control of the citrus psylla may slow down the spread of this disease. The work done in Punjab Agricultural University has shown that 4 sprays of dimethoate 0.06% at 10-day intervals during April-May can eradicate this pest (Bindra and Sohi, 1969).

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Item No. 6(VI)

ALL INDIA SEMINAR ON CITRICULTURE
NAGPUR - 1972

Nematodes and Citrus die-back

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Several species of plant parasitic nematodes have been reported to be associated with citrus in India (cf. Sitaramaiah et al., 1971).

1) Tylenchulus semipenetrans (the citrus nematode)
2) Meloidogyne spp. (the root-knot nematodes including M. africana)
3) Pratylenchus spp, (the root lesion nematodes including P. coffeae)
4) Rotylenchus spp. (R, orientalis)
5) Helicotylenchus spp. (H. digitatus, H. neoformis) (H. dihystera, H. indicus)
6) Hoplolaimus spp. (H. indicus)
7) Criconemoides spp. (C. citricola)
8) Hemicriconemoides spp. (H. communis, H. mangiferae)
9) Paratylenchus spp. (P. nainianus)
10) Xiphinema spp. (including X basiri, X. americanum, X. insigne)
11) Longidorus spp. (L. brevicaudatus)
12) Trichodorus spp.
13) Scutellonema brachyurum (unpublished)

Of these, the citrus nematode undoubtedly is the most important species distributed throughout the country and infesting every cultivated species of citrus. This is the main nematode problem discussed below. The burrowing nematode Radopholus similis which is the causal organism responsible for the spreading decline of citrus in U.S.A. has fortunately not been reported in this country from citrus so far, though the species is now known to be present in Kerala on banana and coconut, and in Mysore on banana.

The citrus nematode

Work done so far in India and abroad:

The citrus nematode (Tylenchulus semipenetrans) has received the attention of nematologists ever since its discovery in 1912 and much work has been done particularly in California and Israel on various aspects of this problem including the role of this nematode in citrus decline, the biology and life cycle of the nematode, effects of ecological factors, varietal susceptibility and methods of control. Other factors like the gross neglect of recommended cultural practices, presence of a hard pan (like kankar in Punjab), deficiency of macro and micro nutrients, water-logging, stock-scion incompatibility, insect pests and diseases, particularly those of viral and fungal origin, etc. have been reported by different specialists to be causes of citrus decline. Although, in most of such studies, the workers have emphasized only the factor falling in their line of specialization, it is most likely that often more than one factor were operating simultaneously including the citrus nematode.

Symptoms of damage:

It is interesting to note that while the nematode infestation by itself can produce disease symptoms like those due to factors mentioned above, none of the latter can cause the root symptoms as by the nematode. Badly infested roots show extensive necrosis which gives them an abnormally dark colour. The branch rootlets are somewhat shortened and swollen and the discoloured roots with soil adhering to the mucilagenous

secretion of the nematodes gives them a rough, irregular and encrusted appearance. Gentle rubbing of roots between fingers will result in the cortex coming off in the form of a sleeve, leaving the middle core intact. In general, the infested trees are less vigorous and show reduction in terminal growth followed by die-back symptoms, produce fewer and smaller fruits which ripen prematurely, are less able to withstand draught, show lack of fertilization effects more quickly than uninfested ones and produce stunting effect on growth (Baines, 1950). The trees are not killed but maintain themselves in a rather sickly condition and produce a small crop of inferior fruits. Many of the plantings may thrive and produce good yields for about 10-15 years before injury from nematodes becomes evident. The ill effects become more pronounced as the trees get older when there is competition for nutrients and moisture between roots and between trees; by this time the nematodes overtake root production and begin to affect top growth. Tylenchulus semipenetrans has therefore been designated as " agent du slow decline " (Vilardebo and Luc, 1961) and it has been concluded that this nematode is the chief cause of the root decay disease " Podredumbre de la raicilla" of orange trees (Marchianatto, 1947).

Young nursery stock planted on infested land may begin to show yellow leaves, defoliated twigs and small fruits within 5 to 10 years. Symptoms will vary considerably in different plantings, depending on soil fertility, moisture, and agronomic practices.

Besides the damage caused by their own infestation, the nematodes help establishment of pathogenic fungi like Thielaviopsis basicola and Fusarium solani (Van Gundy and Tsao, 1963) and F. Solani and F. oxysporum (Feldmesser et al., 1962). However the information available on such associations and disease complexes is limited.

Hosts:

In addition to Citrus spp. and related genera the other hosts of the citrus nematode reported so far include:

Vitis vinifera - grape
Syringia vulgaris L - Lilac
Diospyros virginiana - Persimmon
Olea enropaea L - Olive.

Spread

Moving and planting of infested nursery stock is the most common means of spread of the citrus nematode from one locality to another and this has been responsible for the rapid dissemination of the pest. Citrus plants are usually transported " balled" with roots and soil held together by packing material, an ideal method of moving nematodes as well as trees.

Control

(i) Since the nursery stock may be infested with the nematode, seedlings should be raised only in soil which has been treated with a suitable nematicide (soil fumigant).

(ii) Replanting in plantations which are known to be infested should be done only after sterilizing the soil with a suitable soil fumigant (D-D at the rate of 120 to 180 gallons per acre has been reported to be very effective). However, good control is not obtained beyond 6 feet depth.

(iii) Good nematode control over a 3 to 4 years period has been reported as a result of application of emulsifiable DBCP in irrigation water at the rate of 3-6 gallons per acre (51.6 and 28.5 lb active ingredient) to living trees of over 30 years (Reynolds and O'Bannon, 1958, 1963). Tree recovery was aided and speeded up when this treatment was combined with hedging. There was improved growth, increased yield (23 and 21% increase over untreated), and larger fruits. Secondary damage by Fusarium was also less following treatment. Similar results were also obtained by Oteifa et al (1965) from U.A.R. Van Gundy et al (1960) found that the most satisfactory dispersion of the fumigant (DBCP) was obtained with basin irrigation (6 acre inches of water) rather than by introducing the compound in furrows or by overhead irrigation.

(iv) Efforts are still being made by workers to incorporate the resistance from Poncirus trifoliata to some of the species of citrus root stocks.

In India, Siddiqi (1961) recorded the prevalence of this species for the first time and since then, Siddiqi (1963), Swarup et al (1964), Prasad and Chawla (1964), Chona et al (1964), Bindra (1966) and Bindra et al (1967) found that invariably T. semipenetrans formed the most predominent nematode population wherever citrus die-back symptoms were present. They suggested that this nematode is one of the factors associated with the widespread slow decline and die-back of citrus orchards in India. Besides citrus, grapevine was also found heavily infested with this nematode at Abahar, Punjab (Chona et al., 1964). Bindra and Chhabra (1968) tested the efficacy of DBCP against this nematode and confirmed the usefulness of this chemical under Indian conditions also. According to them the chemical given in irrigation water at the rate of 12 and 24 lit/acre increased the yield by 98 and 141 per cent respectively, thus the cost of the treatment working out to only Rs. 91.00 and Rs. 182.00/acre or less than Re.1 and 2 respectively provided the effect continues for 3 years as claimed by Reynolds and O'Bannon (1964). Bindra (1970) has given a review of the nematode problems and suggested that the currently known methods of control may be adopted on a large scale to combat this pest in India.

It may however be stated that no comprehensive studies have yet been undertaken in this country to study the biology, life history and pathogenicity of the nematode under our conditions, its association with other pathogens like fungi and bacteria, the extent of damage caused by the nematode alone or in combination with other pests/diseases and economical methods of control.

Suggestions for future work in India:

Considering the highly complex and formidable nature of the problem, it is obvious that a cooperative effort of all the disciplines, viz., Horticulture, Soil Science, Nematology, Entomology and Pathology is urgently necessary in

order to force the pace of solution of the problem. Nematodes, particularly Tylenchulus semipenetrans has been reported from all the citrus growing areas of our country irrespective of the presence or absence of other diseases of local importance. Schemes on Citrus die-back, though in existence for nearly a decade in a few places, have never paid any attention to nematodes. In view of the importance of nematodes in the citrus decline complex it is proposed that due emphasis should be given for studies on various aspects of the citrus nematode at least in the future. The following broad lines of work are suggested:

1. An organised survey for nematodes of citrus should be undertaken in the different citrus tracts of the country for assessing the extent of infestation on trees with varying degrees of die-back. The population may vary with the agroclimatic zones, the kind of root-stock, the age of the tree as well as the fertility status of the soil concerned.

2. Studies on the biology of the nematode would be necessary to understand more about the behaviour of this nematode under our conditions. Data on seasonal variations as well as the rate of build up of the nemic population in freshly planted and old orchards would help in deciding the timing of the application of control operations and their economical feasibility.

3. Pathogenicity tests under controlled conditions are necessary to confirm the indications obtained during the survey work, to determine the extent of damage under our conditions and to find out the population threshold that is harmful to the crop with reference to different root stocks, soil types, levels of fertility etc.

4. Another very important aspect of study will be the role of nematodes when associated with other pathogens like fungi, bacteria and viruses and the combined effect on the trees.

5. The role of the citrus nematode and other pathogens in the citrus replant problems.

6. Screening of commonly used and potential root-stock for their susceptibility/resistance to the citrus nematode; studies on the existence of biotypes of the nematode in India.

7. Chemo and physico-therapeutic studies involving bare root dips in nematicidal solutions, hot water treatments etc. could provide economically feasible control measures for disinfesting the infested nursery stock.

8. Field trials with different non-phytotoxic nematicides have to be conducted to find out the most effective and economic treatment for established orchards. A number of chemicals have already been tried in California and elsewhere. DBCP has shown promise for established orchards in India also. Search for a wide spectrum chemical to be effective against fungi, bacteria ,virus vectors and other insect pests and nematodes also seems to warrant attention.

9. Finally the effect of various cultural practices, application of various macro and micro-nutrients to soil and on foliage of infested/uninfested trees will reveal how best to utilize the fertilizer inputs and keep the nematode population below the damage level.

10. Besides, T. semipenetrans, several other species of nematodes belonging to the genera Meloidogyne, Criconemoides, Hemicriconemoides, Paratylenchus, Pratylenchus, Paralongidorus, Hoplolaimus, Hemicycliophora Scutellonema etc. are known to be associated with citrus in different parts of the country and cause damage to the trees. These also require investigation.

To implement the above suggestions, suitable full time nematology staff will have to be provided immediately at 2 or 3 locations to start with. The role of the citrus nematode in the citrus die-back and decline complex has never been properly investigated in this country and it is high time that such investigations are undertaken without any further delay.

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6(VI)

Item No. ~~13(vii)~~

A RESUME OF WORK DONE IN THE DECLINE OF SANTRA (*Citrus reticulata Blanco*) AND MOSAMBI (*Citrus Sinesia osbeck*) ORCHARDS IN MAHARASHTRA.

BY

Phadnis N. A.　　Mujumdar A. S.　　Nevase A. G.

The citrus being indigenous to north eastern India, is cultivated in the country since long. It is now grown in almost all parts of India. The introduction of commercial cultivation of mandarins around Aurangabad dates back to the 13th century, from where it has spread to Nagpur and surrounding areas. The 'Mosambi' sweet orange appears to have been introduced in Western India during the 16th century where it has established as an important cultivated fruit.

Of the area of 93,284 hectares under citrus in India, Maharashtra accounts for more than a fourth, with 24,900 hectares. The citrus industry is of considerable economic importance in the districts of Nagpur, Amraoti, Wardha, Jalgaon, Aurangabad, Ahmednagar and Poona.

Of late the malady of decline of trees locally known as 'dieback' has caused wide spread damage, and has been taking a heavy toll of trees each year. In order to arrest the declining condition and to rehabilities the industry, studies have been in progress since the last five decades and the results achieved have been summerised hereunder.

NATURE OF DECLINE

It is generally noticed that until about 5 to 6 years from planting which marks the vegetative phase, the trees grow apparently normally. With the commencement of fruiting during the initial years of bearing, the decline begins and with the increasing fruiting capacity of the trees, the malady also assumes more serious proportions and by the time the trees are expected to produce full crops, a substantial number of them get affected and quite a few die. The groove becomes uneconomical to maintain within a period of 15- 20 years.

The most common manifestation of the affected tree is that, at first the leaves become chlorotic, yellow and sickly. Later, such leaves drop down presenting bare twigs which start dying from tip downwards. Weak shoots arise from the lower green portions which grow for a while and start withering. Such a condition may be observed all over the tree or only on certain limbs or branches. The trees do not shown normal vigour and are generally reduced in size. The yield is considerably affected. Some times the trees show wilting of leaves in an otherwise healty tree reminiscent of water stress. The wilting progresses further when the

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leaves wilt permanently but remain attached to the tree for qui some time until after the tree is dead. The developing fruits dry before attaining maturity and remain attached to the dead tree. Thus the decline is sudden as compared to the slow death in the die back type of malady. The afflicted trees in both cases have a tendency to bloosom excessively and bear a large crop of small fruits which fail to ripen properly.

CAUSES OF THE MALADY

Early investigations carried out during the begining of the current century pointed out to the fact that the decline of trees was associated with improper selection of orchard sites Cheema and Bhatt (1929) observed that soil containing an excess of lime and deficient in plant food pre-dispose the plants to die work. It was also reported that water logged soils and thos deficient in aeration as well as the ones with hard sub-stratum are responsible for the malady and have cited examples of considerable improvement in the health of trees by providing drainage and adequate nutrition by manuring and fertilization.

Latter Uppal and Kamat (1936) reported the widespread incidence of gummosis casued by the fungus <u>phytophthora palmivora</u> to which the oranges fall an easy prey while the Kagzi lime and the rough lemon (Jamberi) were reported resistant. They have recommended the budding of oranges at a height of 40-50 cms. on the Jamberi for prevention of the disease. The remedial measure suggested for affected trees was removal of diseased bark and treating the exposed wood with creosoril.

The above two findings have helped to establish the basic casuses of the trouble. Even to-day the decline in a large measure is associated with these fundamental factors. The gummosis causes damage to the bark of the tree and ruptures the underlying conducting vessels. This interferes with the normal translocation of food and nutrients casusing diebadk of the affected limb. If the damage is extensive that is covering more than half the circumferance of the trunk, the tree may have a girdled effect with little change of survival.

The citrus roots require sufficient aeration for the respirtory activity for the normal meatabolic functions. Any condition that restricts the aeration such as high moisture content of soil or water table in the root zone destroys the root system to a considerable extent. This in-evitably, hinders the uptake of nutrients and water causing general debility of the plant. Presence of hard sub-stratum essentially restricts the root growth so that the capacity of the plant to forage the soil for nutrients is reduced. Poor soils which lack in the essential plant food are not expected to sustain the health and vigour of the trees in view of the fact that the essential in-gradients are not available to the trees in requisite amounts. Highly clacarious soils and those rich in base elements bring

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about induced deficiencies of certain other elements notably the micronutrients by forming insoluble compounds. The selection of soil for citrus planting, therefore, needs to be done with extreme caution.

The lack of well drained lighter types of soils in the region has been one of the causes of the cultivator utilization the marginal land available at his disposal. For the major part, the citrus soils in Maharashtra are comparatively black, clayey, retentive of moisture and very often deep, generally with fair amount of calcium, potassium and other base elements with the pH ranging on the higher side.

Our soils are deficient in nitrogen and unless this element is supplied through fertilization the trees remain stunted with a pale and sparse foliage and tip drying of shoots and branches. Ranga Rao (1959) has reported that 88 percent of the citrus orchards in the Nagpur region receive only farm yard manure. The quantity applied is 5 cartloads per acre in one third the number of orchards. 5-10 carloads in one fourth the number of and 10-20 cartloads in another one fourth thus showing inadequacy of manuring in the majority of orchards. Phadnis (1961) is of the opinion that the nutritional deficiency is one of the major causes of Santra tree decline in the Nagpur region and has recommended the application of one kilogram of actual nitrogen per adult tree to build up vigour in the plants.

Citrus trees in Maharashtra have been found to suffer from chlorosis of leaves depicting various sysptoms of micronutrient deficiency. The symptoms have been observed especially in the mosambi and the grape fruit in alkaline soils particularly in the rainy season causing dieback of twigs. Parker (1948) is of the opinion that in highly alkaline soils the availability of the minor elements may be greately decreased and the synptoms of the deficiency may develop. Singh (1953) noted lime induced chlorosis in the Nagpur santra nursery plants and corrected the deficiency by injecting the element. Nema (1955) has reported symptoms similar to the deficiency of zinc in the Nagpur santra and has advocated use of organic manures. Nagpal (1963) has reported that the citrus trees in erst-while Bombay State showed deficiency of zinc and manganese and has advocated regular sprays of these elements at least once a year during the growth period. Khanduja (1955) has indicated from a survey of nutritional status of the mosambi trees in Ahmednagar district that the cultivators tend to use excessive phosplatic fertilizers which induces the micronutrient deficiency. Phadnis (1963) in reporting the results of the fertilizer experiment in Nagpur Santra, states that there is no need to apply potasic fertilizer, as the soil contain enough of the element. It is well known that excess of potassium brings about a deficiency of magnesium which may

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of the normal growth and producitivity of plant.

While it is true the nutritional deficiency and imbalance may be one of the principle contributory causes of dieback, not all chloritic sysptoms points out to mal-nutrtion Saplal (1970) observed dieback in mosambi trees at Poona exhibiting mal-nutrition symptoms. He carried out nutritional studies with respect to macro and micro element along with healthy ones and came to the conclusion that nutritional deficiency does not appear to be the cause of declining condition of the trees and that the malady appears to be due to factors other than nutritional.

The virus complex is reported to be a cause of chlorosis and yellowing of leaves, similar to those produced by mal-nutrition. Phadnis (1959) has stated that though in general, the chlorotic pattern of leaves due to deficiency is confined mainly to the intervcinal space, and veiw chlorosis is expressed in virus affected trees over lapping sysptoms are not rare. The general condition of a tree with zinc deficiency closely resembles the virus affected tree and as such both these conditions are liable to be confused with each other.

In 1955 Nagpal (1959) suspected the presence of tristeza virus as a cause of declining condition of citrus in erst-while Bombay State. This inference was drawn by him from the fact that mosambi budlings on the sour orange root stock died within two months of sprouting at the Ganeshkhind Fruit Experimental Station and graft inoculation tests on Kagzi lime indicator plants showed vein clearing and stem pittting symptom This test followed an earlier observation in 1942 in the root stock trial at the same experimental station, in which, attempt to bud mosambi on sour orange root stock had failed. Further, apart from tristeza, he also suspected the presence of xyloporosis and psorosis, thus suggesting virus complex as a cause of dieback in western India. Though the Jamberi root stock is reported to be generally tolerent to tristeza virus facilitating normal growth, the decadence, of trees on this root stock observed in the region due to tristeza is attributed to the differen strains or sub-varieties of Jamberi in use.

Vasudeva and Capoor (1958) have almost simultaneously reported experimental evidence of the presence of tristeza virus in India in 1955-56. Capoor and Rao (1967) report the isolation of three strains of tristeza i.e. mild, severe and seedling yellow and have suggested that by the interaction of mild and the severe strains the mild one may give substantial protection against the latter. The different strains of tristeza virus may also be the cause of variable damage observed in different trees.

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The transmission of the tristeza disease appears to take place through the transplantation of the tissue from affected trees in propagating young plants in the nursery by budding, grafting and other vegetative methods. In the plantation, the disease is transmitted by insect vectors. Capoor and Rao (1967) have established the transmission of tristeza virus by brown citrus aphid. Toxoptera citricida (kirk) and a number of other aphids.

The damage to the tree consequent on being affected by tristeza mainly arises in the stionic combination in which varieties like sour orange, grape fruit and lemon are used as root stocks for tolerant scions such as sweet orange. Such stocks being hypersensitive in reaction, the build up of virus in the scion causes damage to the phloem, reducing the flow of carbohydrates to the stock. The stock scion combination, therefore, greatly reduces in vigour and in severe cases may even be killed.

Certain stionic comibnations were observed for stem pitting at the Citrus Dieback Research Station, Shrirampur. Severe stem pitting was noticed in the combination of Mosambi on Kagzi lime, Satkara and Gajanimma. While that on Gabbu Chinee, Watson Pumello. L-8, Karna khatta and Adajamir showed moderate stem pitting. There were other combinations which were either slightly pitted or not pitted at all. The stionic combinations of mosambi kharna khatta, Rangpur lime and Jamberi in the field experiment on root stocks showed severe strain of tristeza virus.

Capoor (1964) has suggested a systematic survey orchards to locate pockets which may be found free of the tristeza virus and to use them for propagation on tolerent root stocks. Bennet and Costa (1949) have suggested the use of nucellar seedlings in freeding the citrus clones of viruses, as they are identical with the seed parent in genetic constitution and at the same time emerge free from the virus infection. Nagpal (1959) developed nucellar lines in the mosambi which later proved vigorous and healthy in comparison with the old lines. Invigoration of the clone in this manner seems to be a good proposition. However, the plants so raised though virus free to start with, may contract the disease subsequently due to presence of virus all around and the insect vectors being active in all the seasons. The presence of the virus, must, therefore, be accepted and its effects minimized through the use of non-susceptible root stocks and the dessemination of virus by insect vectors be presented by adequate plant protection measures.

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The cause of citrus dieback has been attributed to yet another virus disease viz. that of "greening" by Fraser (1966) who reports it universal occurance in this country. The symptoms expressed by the trees when affected by greening have been reported by Fraser et al (1966) as the conspicusous yellowing of the part immediately adjacent to the mid vein in the mature leaf developed from new vigorous growth made during the growth cycle in spring. This yellowing is reported to spread out along the main lateral veins and in extreme cases to the interveinal tissue. Most of all of these leaves fall with the onset of summer and dieback of the twigs may commence. Excessive blossoming is often associated with it. The chronically affected trees produce leaves in cooler weather with a variety of chlorotic patterns superficially suggestive of zinc or iron deficiency. The chlorosis may be complete or there may be some green in the mide vein and in some main lateral veins. Irregular blotches of green occur anywhere and rather characteristically small round sports of green develop on the yellow tissue.

The disease may bring about the sudden wilt and tree may die with leaves and fruits withered and remaining attached as in tristeza. The fruits reduce in size become lopsided, break colour first on sides exposed to the sun, contain curved collumelas and aborted seed and drop immediately.

The virus is reported to be unevenly distributed in the tree by McClean and oberholzer (1965) and accordingly in the early stages the disease symptoms are manifested on one or two limbs which stand out conspicuously with die back and chlorosis. The transmission of the disease by vegetative propagation may take place in a few but not all cases. In nature however, the spread of the disease appears to take place through the citrus Psylla (Diphorina citri). The ability of this insect to act as vector has been established in India by Capoor et al (1967).

The main damage to the tree seems to arise out of the reduction in the amount of the feeder roots consequent on chlorosis yellowing and sparseness of foliage.

At the citrus Dieback Research Station, Shrirampur chlorotic symptoms of leaves on mosambi scion on different stock similar to the symptoms of greening virus were observed. The symptoms persisted even after the application of zinc sulphate as well as complete nutrient sprays. Similar symptoms were noted on stocks of Billi-kichili, wood apple, grape fruit and Gajanimaa. Sections taken through yellow veins of affected leaves revealed necrosis of sieve tubes and excessive phloem formation, while sections of healthy leaves failed to show such symptoms.

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The control of greening virus is more or less similar as in the case of tristeza affected trees viz. using bud wood from virus free indexed plants or from nucellar lines. Further vigorous control of citrus psylla is necessary. The choice of root stock does not seem to matter much as the scion portion of the tree is primarily affected. Fraser (1966) has suggested the search for a mild strain of the greening virus which may give field protection against more severe strain, in support of which a theory has been advanced that if a plant is already infected with a virus it may be difficult for a second strain of the same virus to be established by means of insect vectors.

Apart from these two established viral disease certain other manifestations of the trees give an impression of virus like condition. These are bud union crease, inverse pitting and woody gall.

In the citrus root stock field trial both at Shrirampur and Poona the bud union crease has been observed in stionic comibnation of mosambi with Jamberi. It develops according to Fraser (1966) as an irregular indented ring on the wood surface at the bud union, gum develops at apparently irregular periods at the cambial face and become burried in the bark as brown gum deposits by growth of new phloem. It can be rudimentary or very strongly developed in old trees results in a rough ring of bark at the bud union. Its development, however, seems to bear no apparent relation to the health of the tree.

Inverse pitting is associated with the deterioration in the vigour of the tree while woody gall development seems to be harmless. The latter has been commonly observed in the Nagpur Santra on Jamberi root stock as well as the Jamberi seedling trees. This has been considered by Fraser (1966) as a symptom of aphid transmitted vein enation virus.

There are other causes for the deterioration of the citrus trees. The <u>indarbela</u> pest is of common occurance which tunnels into the bark and girdles the limb or the entire trunk. The damage that ensues is the same as in the case of bark damage due to attack of <u>phytophthora</u> fungus. It is however easily controlled by the use of a mixture of enthylene dichloride and carbon tetrachloride (EDCT) plugged into the hole in which the borer hides.

Nematodes parasitic to citrus have been noted in sufficient numbers in citrus areas so as to cause damage to the feeding roots. Soil and root examinations of different stionic comibnations in the experimental orchards at Shrirampur revealed heavy infestation of <u>Tylenchulus</u> <u>semipenetrans</u> with the population ranging between 600-5500 per 250 grams of soil. Only two samples of Mosambi on Rangpur lime and Wood

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apple had the least number of 600 larvae. The roots were also impregnated with females of the nematode. Treatment with nemagon applied to soil at the rate of 35 litres per hectare every year in the month of February resulted in drastically reducing the number to 8 to 250 per 250 grams of soil.

Root stock trials have shown that the mosambi scion of Jamberi, Sohmyndong, Rangpur lime, Mosambi, Karnakhatta and Billikichili have shown maximum vigour and productivity, while Herale, Sour Orange, Atlantia and Bengal citron were very poor with the high mortality of plants. The uptake of nutrien by the scion on different root stocks followed more or less the pattern of vigour induced by the stocks.

The nucellar lines scored over the old lines in vigour and production though the initial bearing was delayed in the former. However, in fruit quality, the nucellars produced more acidity which may be obviated by making a selection in the nucellar seedlings. The stionic combinations of nucellars on Jamberi, Rangpur lime, Karanakhatta, Billikichili and Mosambi, therefore, seem to be comparatively free from dieback with a better productive capacity and potential for longer lease of life.

In respect of mandarin scion on different root stocks, Phadnis (1961) has observed Rangpur lime to be the best followed by Jamberi, Jatti Khatti, and Sweet lemon in all round performance. A classification of the trees on the basis of decadence and mortality has shown that the stocks Rangpur lime, Sour orange and Sweet lemon appear to be quite healthy showing the least amount of dieback. Further Rangpur lime and sour orange followed by Sweet lime root stocks have induced the minimum mortality. Similarly these three root stocks were responsible for producing less amount of dead wood by the Santra trees. Jullunduri Khatti induced maximum formation of dead wood as well as maximum mortality and degree of dieback.

One of the chief causes of a stionic combination not working out satisfactory is the lack of congeniality between thestock and the scion. Webber (1948) has explained that a smooth bud union accompanied with similar stock-scion girth of the trunk exhibits harmony that brings about a through and normal fusion of tissues. Such a union is to be desired since the translocation of the nutrients to the top and movement of food downwards is accomplished without much hinderance. It is seen that the combination of Rangpur lime and Sour orange and to some extent Sweet lime with Santra has given the least divergence between the stock and the scion girth indicating a smooth union. It, therefore, appears that the minimum amount of dead wood, degree of decadence and mortality observed in these combinations has a direct

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relation to the harmonious physiological union. However, it is observed that though the combination with Jullundari Khatti is smooth the trees are the worst affected. The anatomical observations made by Kaicher and Saxena (private communication) in the same field trial have shown extensive necrosis of sieve tubes below the bud union which seems to have produced a girdling effect resulting in degeneration of phloem above the bud union. The damage seems to arise from the fact that Jullunduri Khatti which has been indentified as a smooth lemon reacts to tristeza virus more ore less in the same way as sour orange, as observed by obserholzer (1947) in South Africa. Similarly McAlpin et al (1948) indicated the susceptibility of lemon stock to bud union decline. As against this, the Rangpur lime has shown no abnormality of the type observed in Jullunduri Khatti.

In the mosabi root stock trial also the Rangpur lime has produced a smooth union with best all round performance followed by mosambi root stock. The dieback noted in the latter is however ascribed to the attack of phytophthora fungus. Though the combination of mosabi with sour organge and Herale (a strain of Sour orange) is also smooth, the decadence seems have set in due to the infection with tristeza. The union of mosambi with Karna Khatta is smooth and the performance seems to be satisfactory. The greater degree of divergence observed in the combination with other root stocks indicates lack of physiological balance between the united types. Thus it seems necessary to have a stionic combination which is both physiologically congenial as well as tolerant to the various dieases.

From an over all appreciation of the position reached, the following recommendations are made for arresting the declining condition of trees in this region.

(1) Only those sites that have a good drainage capacity should be selected. The soil should have a depth of at least a metre with no hard pan or water table near the root zone. The soil may range form slighly acidic to weakly alkaline. (2) The Santra and mosambi plants should be budded on the Rangpur lime root stock until more congenial root stocks are selected. The budding should be done at a hieght of not less than 40 cms. The bud wood should be taken from virus free trees, known to produce high yield of fruit of good quality and other desirable characters. Selected nucellar lines may also be employed for budding. (3) The tree trunk should be applied with suitable fungicide upto a height of a metre. Irrigation should be applied well away from the base of the plant to keep the soil dry within a radius of about 25 cms. from the trunk. (4) The adult trees should be given about one kilogram of nitrogen per year including 0.25 kilogram in the form of bulky manures. About three fourth part of the total dose should be applied at the time of crop regulation and the

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remaining quantity immediately after fruit set. If the crop is excessive, an additional dose of nitrogen should be given to prevent the exhaution of the trees. Phosphatic and postasic fertilizers may be applied in one dose according to needs if there is indication of deficiency of these elements. To reduce the chlorosis a couple of monthly sprays with micronutrients may be given during the growth period. (5) Irrigation should not be given until the upper 10-15 cms. of soil becomes dry. At each irrigation, the quantity of water to be applied should be sufficient to wet the entire root zone. It is preferable to irrigate alternate rows of plants with each subsequent irrigation, if the soil is more retentive of moisture. Drainage arrangement should be made wherever necessary especially during the rainy season so that adequat aeration is provided to the roots. (6) Regular plant protection measures need to be undertaken for effectively controlling citrus psylla, aphids and other vectors transmitting the viruses with a suitable insecticide like endrin, D.D.T. etc. A spray at the time of crop regulation followed by a second one after a forthnight gives good results. The operation should be carried out both at the time of Ambia bahar and Mrug bahar. Additional sprays may be given as and when necessary. The stem borer attack may be examined occasionally and measures to fumigate the hiding place of the insect by E.D.C.T. should be undertaken. An occasional application of nematicide to the orchard soil will help to keep down the nematode population.

ABSTRACT

Orange cultivation in Maharashtra both sweet and mandarin has received a considerable set back due to the declining condition of trees. The investigation carried out so far has revealed that the malady is caused by a number of factors such as (1) selection of improper sites predisposed to water logging, lack of aeraction, high in lime content and poor in plant nutrients. (2) occurance of gummosis causing foot rot due to attack by the fungus phytophthora. (3) Chlorosis of leaves consequent on malnutrition of trees. (4) infection of virus diseases (5) attack by parasitic nematodes (6) occurance of indarbela and other bark damaging agents and (7) lack of the congenial root stock.

It has therefore been recommended to adopt the following remedial measures to overcome the decadence and to build healthy vigorous trees with good production.

The selection of site should be such as to provide the growth of normal healthy roots. The plants should be prepared by budding at a height of 40 cms. or more on Rangpur lime root stock. The bud wood should be selected from virus free indexed plants or selections made from nucellar

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seedlings for high yield and other desirable characters. The plants should be pasted with fungicide on the trunks and spraying of insecticides should be under taken to prevent the attack of citus Psylla, aphids and - other insects. Remedial measures against stem borer should be adopted and occasional application of nematicides to the soil should be carried out. Irrigation should be given to wet the root zone while keeping the base of the trunk dry. Irrigation interval should be decided on the basis of the driage of the upper 15 cms. layer of soil. Arrangement for adequate drainage should be made. Sufficient nutrition should be provided especially in respect of nitrogen. Micronutrient sprays may be given during the growth period.

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Item No. 6(vii)

NUTRITIONAL ASPECTS IN CITRUS

By

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The Citrus decline has been the subject of considerable research in all the citrus growing areas in the country. Many factors have been considered important in citrus decline such as unfavourable climatic and soil conditions, mismanagement, pests and diseases, virus diseases stionic incomatability or disorders due to involvement of viruses, mal-nutrition (macro and micro) etc., "Citrus die-Back" problem in India can be considered due to a complex involving more than one factor or factors. Factor or factors involved in one region may or may not be involved in another region. On various individual problems or factors involved, considerable work is being carried out in different citrus growing parts of the country.

In other countries nutritional disorders in citrus have been studied by Chapman (12), Chapman and Kelly (13) Haas et al (22) and many others under controlled and field conditions. Under field conditions Pratt and Jones (31) studied accumulation of Phosphorous in citrus soils; Pratt and Harding (32) worked on the fertilisers effect on loss of magnesium from the soil. Response to nitrogen fertilization was obtained in the trials conducted by Jones and Emblton (23). Young and Koo (40), Cary(11), Smith (38) and Jones et al (24). Similarly the work on Potassium requirements in citrus was emphasised by Embleton et al (19), Bredell (9) and Weir(39). The nutritional requirements of citrus has been extensively investigated in Florida, California and Isreal. But the findings from these countries may not be applied to their entirity to citrus grown in India, although they serve as useful guides.

Dutta (18) in Assam found deficiency of Cu and Zn in citrus in lateritic soils and got response to sprays of copper sulphate with Pummelo,

Copper and Zinc sulphate sprays with le mon. Govinda Iyer and Iyengar (21) found that total nitrogen, phosphoric acid and potash were satisfactory in orange orchards of Wynaad but availability was very low. They attributed low availability to low pH (5.50 to 5.67) and poor lime status. Dhingra and Kanwar (16) in Punjab found the soils of chlorotic plants to be deficient in exchangeable Cu, Zn and Fe and high in Potash and Lime. Kanwar and Randhawa (25) in Punjab suggest from soil and leaf analysis of citrus, that chlorosis caused due to salinity high uptake of P and Mn reduced Zn and Fe. Aiyappa and Subramanium (3) in Coorg, obtained partial recovery of orange plants by using different chelated compound with fitted copper and Sequestrene Zinc treatments. In Punjb, Khanna et al (28) studied the comparative efficiency of chelated and unchelated compounds on Citrus chlorosis and found that the up take of Zinc and copper by leaves of 4 years old sweet orange trees when they were applied through foliar spray either as sulphate salts or as chelates using separately E D T A. Anand et al (8) studying chelated and unchelated compounds with respect to zinc and copper on citrus chlorosis and chlorophyl contents, found maximum percentage or reduction on chlorosis by Zn-HAD treatments. They observed which in turn is conditioned physiologically to a great extent by the presence of adequate amount of Zinc and Copper. Aiyappa and Subramanium (4) found significant response to Phosphorous application. Dikshit (17) found that young chlorotic mandarin plants recovered by nitrogen fertilization (1 lb ammonium sulphate or Calcium ammonium nitrate) and spraying with Zinc diethyl-dithiocarbamate at 34 gms per 4 gallons of water.

Prediction of responses to applied micro-nutrients can be considerably improved if information from visual symptoms, soil analysis and plant analysis and field expriments are taken into account simaltaneously. In case of plantation crops (fruit plants), the trees with healthy root system penetrate deep into the sub soil and tap the available plant food elements, therefore greater reliance has to be placed on plant analysis for predicting responses to nutrients. Mukerjee (30) reported that Zinc, Manganese and copper were present in low concentrations in diseased leaves of citrus collected from Punjab, Coorg and Madras

when compared withthe healthy leaves. Randhawa et al (33) in Punjab studied the role of soil and plant decomposition in diagnosis of citrus decline and found that deficiencies of Zn, Fe, & Mn are associated. Kavinandan et al (27) analysed the citrus soils in Vidharbha for available copper content. Ghandi and Mehata (20) determined Bo content in leaves of grape fruit, Italian lime, Kagzi lime, Narangi, Pummelo etc. Chowdury (15) reported in Assam, deficiency of B, Zn and Fe in Sour orange, mandarins and Valencia respectively. He recommended application of 1 lb. Borax to soil or spraying 1 oz. Borax in 3 gallons of water for Boron; spraying 10 lb of zinc sulphate plus 5 lb lime in 100 gallons of water for zinc and ¼ lb ferrous sulphate in 100 gallons of water for iron deficiencies, as a corrective treatment. Soil application of zinc and iron compounds gave slow and some times uncertain recovery results. Singh et al (37) recommended Farm Yard Manure and Ammonium sulphate at increased dosages with the age of the trees from 1 to 10 years for higher yields.

In Coorg, Aiyappa (2) found, the level of ash, total N, P_2O_5, K_2O, CaO and MgO lesser in content in diseased mandarin leaves as against the levels in healthy leaves. Kanwar et al (26) in Punjab found higher contents of N, Ca, Mg, and Zn in healthy while P and K contents more in chlorotic leaves. Ali et al (1) studied the effect of foliar sprays of Zn, Mn, Fe, Cu and Co, three times a year on Pineapple and Rough lemon in Punjab and found increase of fruit set with Cu, decrease in fruit dropping with Zn and Mn and increase with Cu, Fe and Co. Singh and Agarwal (36) in Uttar Pradesh recommended that 'N' schedule for 1 to 7 years old mandarin should be same as that used for Sweet oranges i.e. 6 ozs increasing to 36 ozs. of N per tree per year. Singh and Randhawa (35) studied seasonal changes in mineral composition of twigs of different growth flushes in Sweet orange and found maximum N.P.K. in young twigs, N increased, C/N low in young leaves; Ash and Calcium contents showed increase in increase in age. Aiyappa (2), while reporting the nutritional status of the soil under different experimental blocks at Citrus Die-back Scheme, Coorg, observed a wide variation within a small area of 20 acres inthe contents of N, Ca, available K and total exchangeable bases and Mg. Kumar and Sharma (29) found increase of chlorophyll content in chlototic leaves after treating with Zn, Cu and Fe.

Mineral nutrition deficiencies occur commonly in light, acid soils and where leaching occurs as well as in soils where high salinity prevails. Deficiencies of Nitrogen, Zinc, Manganese, Copper, Magnesium, Boron, Molybdenum and Iron are important in causing mal-nutrition symptoms in citrus trees under field conditions.

From the above it is seen that some workers have attempted to study nutritional problems of citrus in the Country, but much reliable data from well planned and substanced field experiments are lacking. In the citrus growing tracts of Mysore State (Malnad), the most conspicuous sympton of die-back of citrus accompany various types of chlorosis of foliage resembleing the symptoms of mal-nutrition of various macro and micro-elements. Towards this direction works were undertaken on the lines such as: 1) Micro-nutrient spray trial at the station farm, 2) Micro-nutrient spray with different combination in private orchard, 3) Multiple spray trial at the station farm, 4) Leaf nutrient status in healthy orchard trees, 5) Relationship between yield and leaf nutrient content and 6) Relationship between symptomic orchard leaf nutrient content with the healthy orchard leaf nutrient status.

In this paper, some of the salient features of the results obtained regard to nutritional studies conducted on the line mentioned in the above para are included in relation with the problem of citrus decline in Coorg.

1) <u>Micro-nutrient spray trial</u>: To study the effect of foliar treatment of various macro and micro elements individually, super-imposed with soil application of macro elements (NPK) with and without irrigation during drought period (when the soil moisture in the drip circle falls below 10%) a trial was initiated during 1955.

From different years observations on aspects of chlorosis percentage and yield, it has been observed that under irrigation regimes (at the rate of 320 gallons per plant irrigation once in 15 days and irrigation once in 30 days showed significantly more girth and volume than no irrigation. In the foliar treatments, the elements Zn, Mn, Cu and B gave comparatively more girth, height and volume than water (Control). The spray treatments Zn, Mn, Mg and Cu gave significantly lesser chlorosis percentage.

2) Micro-nutrient spray trial in growers field:

In a demonstration spray trial in a 21 year old neglected orchard at Mocha, it was found that the treatments Zn and Cu singly and those in combination of these two elements gave reduction in chlorosis percentage and significant increase in the yield. This corroboratory evidence was of immense value and the orchardists have convinced to give nutritional sprays as one of their regular orchard practices. It is note worthy to point out that the orchardist, who was not getting any income from the plot taken for experimentation before the experiment was laid, realised more than Rs. 10,000/- in the third year of the treatment in a unit area of about 5 acres.

3) Multiple spray trial: In another trial laid out at the station farm at Athur, to study the effect of foliar treatment of various macro and micro-nutrients in combination with soil application of major elements (NPK) and the effect of witholding one of the micro-nutrients under field condition on seedling mandarin trees was undertaken. Seven elements Zn, Mn, Mg, Cu, Fe, Mo and B were tried as sprays, leaving out one element in each treatment and giving the spray of each element on successive days instead of on the same day to avoid possible interaction and selective absorption. From the data collected, it was noticed that the treatments receiving all elements but (-B), (-Zn), (-Mg), (-Cu) and (-Fe) recorded comparatively more girth and volume than control. The treatment trees receiving -Zn, -Mn, -Mg and -Cu have recorded higher percentage of chlorosis which emphasises the importance of Zn, Mn, Mg and Cu in the inclusion of manuring spray schedule for Coorg orange in this tract.

The above studies have revealed the importance and involvement of certain micro-elements apart from providing proper cultural practices and control of pests and diseases in preventing the tree decline condition in citrus plantations.

4) Studies on the nutritional status in mandarin leaves: For studying the nutritional disorders in crops, soil analysis coupled with analysis of the leaves of healthy and symptomic trees has been considered as one of the

criteria. In India, not much work seems to have been done, to have standards for mandarin orange (*C. reticulata* Blanco), under Indian conditions. An attempt has been made to establish tentative nutrient status in mandarin leaves collected from healthy, high performing, productive seedling mandarin trees at the citrus die-back research station, Gonicoppal.

Orchards possessing, healthy, high performing and productive seedling mandarin trees were located at different zones in Coorg. Matured 5-8 months old leaves from these healthy trees were collected yearly from both fruit bearing, (Chapman and Brown (14)) and non-fruit bearing (Reuther and Smith (34) terminals and their nutrient contents for both macro and micro-elements were determined. Preliminary reports on such studies were reported in an early papers by Aiyappa et al (6 and 7). Based on further data collected in this direction, the tentative leaf nutrient status for mandarin orange arrived has been given below:

Table showing percentage ranges of macro-elements and ppm ranges of micro-elements in healthy seedling mandarin orange trees:-
(On even dry weight basis)

Leaves collected from	N	P_2O_5	K_2O	CaO	MgO	Cu	Zn	Fe	Mn
Fruit bearing terminals	1.820 to 2.484	0.206 to 0.297	0.977 to 1.792	4.128 to 5.964	0.501 to 0.799	20.0 to 174.0	36.3 to 97.2	100.0 to 155.0	52.0 to 123.6
Non-fruit bearing terminals	2.002 to 2.788	0.214 to 0.347	1.042 to 2.487	3.332 to 5.852	0.403 to 0.788	20.4 to 173.6	35.8 to 96.8	103.0 to 171.0	51.8 to 124.0

Based on the levels arrived at the station manurial dosages are being formulated and applied. There is an encouragement on following the dosages based on this line.

5) <u>Relationship between yield and nutrient levels</u>: In an attempt to study the relationship between yield, and nutrient contents in leaves, leaf samples from non-fruit bearing terminals were collected from trees having different yield ranges in two different zones and analysed for both macro and micro-elemental

contents. Comparison of different macro and micro-elements content with those of the non-fruitbearing terminal leaves tentative range, (except in few cases). There was observed yearly decrease in the yield and reduction in the macro-element contents in the leaves.

6) <u>Studies on the symptonic orchard and healthy orchard</u>: In another trial to study the relationship between symptonic orchard leaf nutrient contents with that of the healthy orchard leaf nutrient contents, work was started in Coorg. Nutrient contents in the non-fruit bearing terminal leaf samples collected from symptomic orchards were analysed.

Comparing the results of the nutrient contents with nutrient status of non-fruit bearing terminal leaves, it was noticed that most of the macro elements content fall within the level except nitrogen and calcium. With regard to micro-nutrient contents, most of the elements Zn, Fe and Mn fall within the tentative level, except in few cases. The Cu contents were less than the suggestive level in all cases.

From the various types of studies conducted in Coorg in regard to nutritional aspects, it can be said that there is a response to sprays. Thus proper fertilization including spraying with micro-nutrient are important in citrus growing along with other aspects such as disease and insect pest control, cultural practices etc. Orchardists are now awakened in this respect and there has been response from them to take up the operation of micro-nutrient spray and proper fertilization.

Summary and suggestions:

In this paper some of the works relating to nutritional aspects in citrus growing done in the country has been dealt. The studies with regard to foliar supply of nutrients carried out at Citrus Die-back Scheme, Gonicoppal centre have been reported and they have given encouraging results in maintaining tree vigour and reducing chlorosis condition of the trees.

Taking stock of the situation on nutritional aspects, in the Country, it is seen that some work on this line have been done in certain citrus growing

areas but much remains to be tackled. Proper thought for fertilizer utilization should be given in the nutritional supply to citrus plants. Comprehensive studies in the nutrition of citrus are needed. Since application of fertilisers from the largest single aspects in producing citrus.

Studies under nutritional aspects to elucidate and to understand deficiencies and excesses of various essential elements, fertiliser requirements, correlation of nutritional levels with rootstock for different commercial varieties are essential. Leaf and soil analysis technique must be made popular with the growers as a guide in recommending correct manurial schedules. For this purpose nutrient levels (both for macro and micro) for commercial varieties must be evaluated and fixed by soil and plant part analysis technique Considering the lacuna in the Country regarding citrus nutrition some of the works which need attention of our scientists working on citriculture are suggested. They are:-

1. The critical levels in leaves of different commercial varieties of citrus grown in the Country should be worked out to farm guide lines.

2. Development of deficiency symptoms of different elements (macro and Micro) has to be made and a monogram made available to research workers/extension workers to serve as guide line in detecting the mal-nutrition in plants.

3. Nutrition status of trees in relation with different rootstock should be conducted.

4. Correlation studies of nutritional status with aspects like virus infection, disease and insect pests to be done.

5. The nutritional status in leaves of citrus plants in different years (ages) of planting may be studied so that proper guidance of correct fertilization at different ages can be worked out.

6. Nutritional studies in relation to viruses-Tristeza and greening-under controlled conditions may be initiated. Virus fungal complex and nutrition in relation to die-back of trees need emphasis.

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ABSTRACT

Improper fertilization and mal-nutrition due to one or more nutrient elements has been considered as one of the contributory factors involved in the problems of citrus decline in the Country.

Although works in this direction has been done but it is felt further planned studies are needed. Some of the recommendations for taking up future research works on nutrition in citrus are:-

1. The critical levels in leaves of different commercial varieties of citrus grown in the Country should be worked out to farm guidelines.

2. Development of deficiency symptoms of different elements (macro and micro) has to be made and a monogram made available to research workers/extension workers to serve as guideline in detecting the mal-nutrition in plants.

3. Nutrition status of trees in relation with different rootstock should be conducted.

4. Correlation studies of nutritional status with aspects like virus infection, disease and insect pests to be done.

5. The nutritional status in leaves of citrus plants in different years (ages) of planting may be studied so that proper guidance of correct fertilization at different ages can be worked out.

6. Nutritional studies in relation to viruses-Tristeza and greening-under controlled conditions may be initiated. Virus fungal complex and nutrition in relation to die-back of trees need emphasis.

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Item No. 6(VIII)

ALL INDIA SEMINAR ON CITRICULTURE

NAGPUR - 1972

CITRUS DIE-BACK IN MYSORE STATE

By

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For many years citrus cultivation in India has been known to suffer seriously from certain disorders which adversely affect its growth vigour resulting in loss in production, dying back of twigs and branches, gradual death and sometimes sudden wilting of so called healthy looking trees. These symptoms of the affected citrus trees have been referred as "die-back" disease. It has been observed in Assam as early as 1888, and in Bombay State in 1912 as a serious disease of the citrus trees.

Little had been known until recent years about the various causes that bring about the die-back symptoms almost in all citrus plantations. It is believed to be caused by several factors such as poor soil, water logging, bad nutrition, fungi, viruses, mycoplasma and nematodes.

In India, a few of these viz., three virus diseases namely, tristeza (Vasudeva and Capoor 1958, Nagpal, 1959; Reddy and Rao 1961; Capoor 1963; Nariani et al. 1965), exocortis (Patil and Warcke 1968; Nariani and Raychaudhuri 1968), tumour (Capoor et al. 1968, 1969), and a new mycoplasmic origin (MLO) namely 'greening' (Capoor et al. 1967), have so far been recorded. In this paper, a few diseases which occur or which have been of recent detection in Mysore State are described and discussed for their possible control measures.

1. Tristeza or quick decline:

Distribution: Coorg, Sakleshpur, Bangalore, Bellary.

This disease was first recorded from Bombay State, and in fact this virus is perhaps associated with almost all the commercial citurs cultivators. It is difficult to locate any citrus plants free of tristeza.

The first evidence of the disease in sweet orange or mandarin are the partial or complete suppression of new flushes of growth and the appearance of various types of leaf

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discoloration. Older leaves may become dull and show chlorosis of major veins. Leaf fall continues towards the until many twigs are practically defoliated. Weak shoots begin to grow out of axillary buds, mostly in a vertical position. These shoots produce small and paler leaves with yellow midribs or main veins remaining yellow. Limbs begin to die-back from the tips and more weak shoots are produced from the main limb and trunk. Such trees sparse foliage mostly in a semi aric condition, few flowers, and shy bearing. Diseased trees have tedency to blossom heavily (severe strain) in the early stages of attack, and usually bear plenty of immature fruits.

Tristeza produces vein flecking in Kagzi or Mexican lime, and stem pitting in limes, citrons, grape fruit and mandarins.

In Coorg area, where the common practice of growing Santras is by planting seedlings only, though now rough lemon as root stock is being used in some areas. The grafted santra seedlings show pittings both on the scion and stock portion (rough lemon). Citrus varieties budded on sour orange, grape fruit, acid lime, citron or C. pennivecicolata are highly susceptible to quick decline. It is also observed that trees of acid lime or Kagzi lime is more sensitive to decline than mandarins or sweet oranges.

Vectors: In these tracts, Toxoptera aurantii B.d.F., Toxoptera citricida (Kirk.), and Aphis grosypi Glover infestations are found throughout their active plant growth.

Strains: In Coorg area, presence of at least severe strain and seedlings yellows (non sap transmissible) strain have been recorded so far. Association of other strains with tristeza and their transmission by different vectors are under investigation. The seedlings yellows strain cause inverse pitting.

Control measures: It is recommended that the bud sticks should be selected from virus free mother plants and grafted on resistant stock. The root stock should preferably be a tolerant or resistant ones such as Rangpur lime, Sweet oranges, Cleopatra mandarin and trifoliate oranges. It is necessary that the suitability of the stocks for different regions should be worked out.

2. 'Greening'

Distribution: Coorg, Sakleshpur, Bangalore, Citradurga.

It is a malady that affects the quality of fruits. The greening disease of citrus has been present for nearly 30 years in South Africa, but it was reported in India only a few years back (Fraser et al. 1966, Capoor et al. 1967, Raychaudhuri and Nariani 1969). It has since been known to infect sweet oranges (highly susceptible), mandarins, lime, lemon, grape fruit etc. Greening disease seems to be more destructive than tristeza.

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Severely, 'Greening' affected trees are stunted, Unthrifty, sparsely foliated, and produce deformed fruits. Greening symptoms are more conspicuous in young leaves of the vigorously growing plants. The early symptoms on leaves of sweet orange and grape fruit followed by general chlorosis of terminal leaves and yellowing of veins in the subsequent leaves and often greening islands on a chlorotic back-ground are found. In severe cases complete chlorosis of leaves are observed. In early stages, the disease is manifested in one or a few branches, and these symptoms can be conspicuously noticed even from a distance. Fruits of diseased trees are lopsided, small and remain unripe for a long period. On fruits generally one sees sun spot.

The mandarin trees though harbour the disease, they are generally slow to show the symptoms than sweet oranges. The disease is transmitted by spsyllid vector, Diaphorina citri Kuway in India.

3. Stubborn:

Distribution: Bangalore, Coorg.

In Coorg area, some of the citrus trees have shown 'Stubborn' type of symptoms. The difference between greening and stubborn symptoms are more or less same. In 'Stubborn' affected, the plants are very much stunted and show different degree of chlorosis pattern. Presence of Trioza erytreae or Trioza sp. in association of the stubborn is suspected. Attempts are being made to study the epidemiology of the disease. The presence of the disease has been confirmed by Dr. Wallace and Calavan, during their visit in 1971.

Control Measures:

Since the causal agents of 'Greening' and 'Stubborn' are mycoplasma-like organism or a mycoplasma, the control measures can be adopted by spraying antibiotics like achromycin, aureomycin etc. as recently reported by Raychaudhuri et al. (1971). Heat treatment of the plants may not be of any practical use, since the vector or vectors are perhaps abundant.

In areas where the disease is recent introduction or suspected, the entire plantation should be sprayed with a systemic insecticide and followed by removal and burning of the affected plant.

Multiplication of budwood material from certified trees are essential.

Also evolving resistant rootstock or resistant scion/stock combinations are necessary. Already work is in progress in some of the centres.

4. Tumour:

Distribution: Coorg.

Capoor et al.(1968) reported a tumour from sweet orange (Andhra Pradesh). They transmitted the disease from a mixture of tristeza on sweet orange to lime, and other hosts by means of grafting and by dodder.

In Coorg area, recently a tumour disease was observed on Sweet orange rough lemon (Chetalli) and on Santhra Kodaikithuli (Gonicoppal). The disease was associated with greening and tristeza.

The plant showed tumour of various sizes on various twigs, branches and even on the trunk.

The tumour disease has been recently transmitted to Kagziline by a species of local dodder (not identified). Its relation to 'Woody gall' reported by Wallace and Drake (1953 a, b, 1961) and(Capoor et al. 1969) is being investigated.

Control:

It is recommended to report and burn such plants, which are of sporadic nature, so that further spread of disease by their vectors or through buds are avoided.

5. A new sap transmissible virus:

Lisbon lemon seedlings 8 years old plant at Chetalli was showing somewhat stunted growth and sparse foliage. The leaves showed erinklyness and yellowing of the main veins. There was no other symptoms such as peeling of bark, or stem pitting.

Transmission of the disease:

Grant and Corbett (1960) first reported the mechanical sap inoculation of citrus variegation virus. Since then there have been reports on the mechanical transmission, which have been included by Childs (1969).

Disease transmission studies were conducted by leaf patch grafting and by means of sap inoculation methods followed by Grant and Corbett (1960, 1961, 1965) using 20% sucrose solution W/V, 0.05 gm activated Charcoal, and at pH 7-8.5 using carborundum 400 mesh. Test plants used were sweet orange (Pineapple, Valencia and Sathgudi), grape fruit (Marsh Seedless) sour arrange *Nicotiana tabacum*, *Phaseolus vulgaris*, *Vigna cylindrica* (Black eye), *Gomphrena globose* and *Crotalaria striata*. The disease symptoms appeared in sweet oranges in about 25 days (26° - 29°C).

The work on other physico-chemical properties is in progress.

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Role of citrus nematodes in the die-back disease:

Several types of nematodes are known to be destructive (under favourable conditions) to citrus. As far as our soils are concerned, *Tylenchulus semipenetrans* Cobb. and *Radopholus similis*. Thorne perhaps cause more damage than any other nematodes, listed (atleast 10-12 species identified on citrus in India.

Symptoms and diagnosis: The nematodes do not kill the citrus, but induce the plants to poor growth, poor yield and end in their death. The first symptoms of nematode attack are those of malnutrition. Leaves are all mottled or chlorotic. Later on the twigs die back, and the fruit size and yield are also reduced.

Recently Oostenbrink made survey collection in these tracts, and he was of the opinion, that the nematodes are not so destructive as other pathogenic agents.

Itis, therefore, suggested that even though the nematode population is there, it can be checked by growing plants like Marygold and other plants whose roots and root exudations are toxic to nematodes. Also other nematicides like nemagon and others are used to control.

Nutrition:

It is now well understood, that malnutrition is one of the factors responsible for citrus die-back. A study of the decline of orange trees in Kerala showed that poor nutrient condition of the soil was the greatest single factor responsible for decline. In Coorg area, many declining trees were restored by judicious manuring and by foliar feeding with macro and micro elements like Zinc, Magnesium, Manganese and Boron. This aspect has been fully worked out by Aiyappa and Srivastava at Gonicoppal Research Station and nutritional spray recommendations have been evolved for the citrus cultivation as far as Mysore State is concerned.

It is suggested that such nutritional requirements of citrus plants in various regions may be recommended depending upon the soil, climatic and plant nutritional conditions.

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Item No. 9

ALL INDIA SEMINAR ON CITRICULTURE

NAGPUR - 1972

BREEDING OF CITRUS ROOTSTOCKS AND VARIETIES TOLERANT TO DISEASES ETC.

By

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Whereas bud sports have given some useful new scion types, hybridisation has given better results in the evolution of new Citrus rootstock. Fortunately the different species of citrus cross with each other easily. The genera Poncirus and Fortunella also cross with Citrus readily. The phenomenon of polyembryony is both a handicap and a boon in the breeding of citrus. Whereas it makes the recovery of sexual seedlings from numerous vegetative seedlings difficult it also makes the perpetuation of hybrid types easy. Most of the new scion varieties produced by hybridisation are tangeloes etc., where a mandarin was one of the parents. On the other hand, the hybrid citrus rootstocks are generally derived from trifoliate orange.

The pioneers in this work were Swingle and Webber, who started their work in U.S.A. before the turn of the century. This stage of the work has been adequately reviewed by Cooper et al (1962). The trifoliate orange was generally used as the seed parent and wide variability was found among the F_1 population on account of the heterozygosity of the parents. However, generally F_2 populations could not be obtained on account of sterility and high polyembryony of the F_1 populations. The hybridisation done at this stage aimed at getting cold hardy scion types. None of the bybrids thus produced proved successful as a cold hardy scion, but many citranges resulting from crosses between trifoliate orange and sweet orange turned out to be very useful rootstocks. These usually were resistent to tristeza virus, Phytophthora fungus and in many cases to the citrus nematode. Some citranges like the Troyer and Carrizo when used as rootstocks

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gave trees of standard vigour while the others like wilitis (and Citrandarin) were dwarfing, but productive all the same. (Gardner and Horanic, 1967).

In the reciprocal cross between trifoliate orange and Ruby Sweet Orange many useful citranges were obtained. It was noticed that some combinations are most successful in giving useful hybrids. Morton, Rustic, Savage, Cunningham and 7 other citranges resulted from a single fruit of a cross between trifoliate orange and single flower of Ruby Orange. The only other important citrange rootstock is the Troyer, which resulted from the cross Washington Navel x trifoliate orange. In the cross between grapefruit and mandarin also, it has been found that certain combinations give more useful hybrids.

In all citranges most leaves are trifoliate, all of them are evergreen and the acrid flavour and cold resistance of the trifoliate orange are inherited. Because of the bitterness of the juice, the citranges were not successful as cultivated varieties.

During the period 1908 to 1914, these workers produced hybrids between trifoliate orange and various varieties of mandarin, lime, lemon, grapefruit, sour orange and kumquat. These crosses also resulted in hybrids with acrid flavour and did not give any type with edible fruit (Traub and Robinson, 1937).

The citranges were back-crossed to the trifoliate orange and the other citrus parents. The fruits of these hybrids were also bitter and they did not become successful as scions. The only two exceptions are the Thomasville citrangequat (Swingle and Robinson, 1933) and Glen citrangedin in which the bitterness was very slight. Both of these varieties are more cold hardy than the citranges.

Even though the original hybridisation involving trifoliate orange did not yield the required cold hardy scions, typos by using other citrus types work has been continued to obtain cold hardy. In California, seedlings of the cross Clementine x Tanako have proved most cold hardy and in Louisiana, where the cold is less severe, the cross Wilking X Owari, Clementine X Wilking and Wilking X (Clementine X Owari) gave a high percentage of cold tolerant seedlings (Furr et al. 1966). Clementine X Wilking, Wilking X Temple have also been reported to be successful in Texas in getting cold hardy types, unlike grapefruit

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and Rangpur lime (Young and Peynado, 1967).

Work on induction of cold hardiness in scions as well as rootstocks has been done extensively in Russia as is to be expected in the cold climate prevailing in the citrus growing areas of that country. Mikautadze (1968) found that hybrids between mandarin and grapefruit and mandarin and pummelo give hybrids which are frost resistant in the Black sea area, have fruits of good quality and ripen early.

Gogiberidze (1966) also found that hybrids between mandarin and pummelo, Clementine and *C. sinensis* have also given frost resistant hybrids. Washington Navel Orange has also been crossed with winter hardy types like trifoliate orange and *Citrus ichangensis*. One hybrid, 'Micurins Glory' has been found to be a good frost resistant type (Surguladze, 1969). Other frost resistant hybrids of similar background have been reported by Bgashba (1970). These also include hybrids between *Citrus unshiu* and *Citrus grandis*. The lowest temperature tolerance range of these hybrids was from -10°C to -17°C, and the hybrids were found suitable for preparation of juice. Bahtadze (1968) also reported that the species with high resistance to frost, such as trifoliate orange and mandarin have high dry matter content and have less active photosynthesis, respiration and transport of nutrients. This is besides the fact that in the trifiliate orange, winter dormancy starts several weeks earlier and the plants remain dormant several weeks later than the other *Citrus* species.

In citrus the resistance to nematodes is an extremely important consideration in evolving new rootstocks. The trifoliate orange has been found to impart resistance to *Tylenchulus* nematode to a large proportion of its hybrids. (Cameron et al, 1954). The hybrids of trifoliate orange with Rough lemon, Kusaie lime and Clementine mandarin have also shown resistance to nematodes (Baines *et al.*, 1967 . *Severinia buxifolia* is highly resistant to nematodes (Vanguncy and Kirkpatrick, 1965) and seems to be useful for further breeding.

Cameron et al (1969) have made several crosses of the trifoliate orange with sweet orange, Rough lemon, Clementine, Rangpur and Kusaie limes, Troyer, Selection 1416, *Citrus macrophylla*, *Sukega*, (a hybrid

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of grapefruit and sweet orange) and some others. They have found that hybrids of the resistant types show resistance in the seedling stage and the inheritance was somewhat quantitative. The resistant hybrids were not always among the vigorous ones. Some resistant hybrids failed to produce fruits. The vigour of the hybrids varied greatly. The hybrids of Rough lemon and mandarin-limes were weak, but all Sukega and Ruby hybrids were vigorous. The hybrids of parents like Clementine and Sukega which have low or no polyembryony, were found not to give any nucellar seedlings and therefore, could not be useful as rootstocks. In most cases the inheritance of this character seems to be simple.

Some work has also been done to evolve citrus rootstocks resistant to the burrowing nematode (Radopholus similis). Sources of resistance to this nematode have been reported by Ford (1969). Estes Rough lemon, which is similar to the ordinary rough lemon, has been found to be tolerant to this nematode. Milam (a hybrid type) which is susceptible to the citrus nematode (Tylenchulus) is also resistant to this nematode. Sweet orange has not shown any burrowing nematode and Carrizo citrange and "Sanguine Grosse Ronde" sweet orange has been found to be tolerant. Crosses between Estes Rough lemon and Trifoliate orange did not give hybrids superior to the former parent. The cross Milam X Citropsis gilletiana was not successful. Unfortunately Milam was found to be severely damaged by Phytophthora parasitica. But Carrizo and Algerian Navel showed no symptoms of this fungus.

Another important aspect of the development of new rootstocks is their tolerance to salt, which is assuming importance in many countries. Work has been in progress in California to evolve salt tolerant rootstocks. Chloride tolerant rootstocks like Cleopatra, Sunki, Shikowasha, have shown in their hybrids that inheritance of salt tolerance is quantitative. Hamlin sweet orange budded on Rangpur x Marsh has shown lower chloride content than on Cleopatra, but the most promising type was the hybrid Christian X Cleopatra. The growth habit of the plants on the latter was as good as on Troyer (Furr & Ream, 1968).

In Italy, Calabrese (1968) has reported that C.macrophylla has proved to be most suitable salt tolerant rootstock for lemons along with Secaton

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citrange, and Citrumello, which is a suitable root-stock for lemons as well as oranges. Troyer and C. taiwanica also were found to be suitable. The use of Cleopatra was limited by its susceptibility to summer rots, inspite of high salt tolerance.

At Dhaula Kuan in H.P. Kagzi lime has been crossed with Galgal (Hill lemon) to get a lime free from citrus canker (Anon, 1966). In Philippines, hybridization for resistance to rind borer and citrus canker was attempted by Torres (1942 and 1936).

It is seen that whereas citranges like Troyer, Savage, and Mortorn have already become established as rootstocks resistant to Tristeza virus, nematodes and Phytophthora fungus, work is being continued to get citrus rootstocks resistant not only to these maladies but also resistant to trunk borer and diseases like citrus canker. In Russia, emphasis is being laid on the evolution of cold hardy rootstocks as well as scions. It is likely that in the future a source of resistance to other diseases and viruses like the Greening may also be found.

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ABSTRACT

The Breeding of Citrus was started in America before the turn of the century by Swingle and Webber and their colleagues. This work did not succeed in obtaining cold resistance scion varieties but yield many important citranges like Troyer, Savage and Morton etc., which have proved to be excellent rootstocks resistant to Tristeza virus, Citrus nematodes and <u>Phytophthora</u> fungus. Further work is in progress in California and in Florida to produce cold hardy types, disease resistant rootstock and rootstocks resistant to salinity.

In Russia considerable work has been done on the breeding of cold resistance types. In this work the trifoliate orange, the Satsuma mandarin and some other Japanese types have been used as parents. Some successful hybrids have also been reported.

Breeding for disease, insect-pests resistance have also been reported by the Philippines but this work does seem to be pursued vigorously. In India work on breeding for resistance against citrus canker has been reported at Dhaula Kuan in Himachal Pradesh.

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Item No. 9(1)

ALL INDIA SEMINAR ON CITRICULTURE

INDIA - 1972

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BUDWOOD FROM NUCELLAR LINES - A PROMISING SOURCE IN THE CITRUS BUDWOOD CERTIFICATION PROGRAMME

By

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It is now well known that primary source of infection of citrus viruses is through budwood. Virus infected trees are short-lived, unthrifty and are in a perpetual state of progressive decline. Optimum production levels in citrus orchards cannot be expected as long as virus infected plant materials are indiscriminately distributed by the commercial nurserymen. We do not have any definite method of curing citrus viruses once the plants are infected. Prevention of primary infection through budwood is considered a logical method. Consequently, a complicated indexing programme of the existing promising parent trees for their virus status was launched in California in 1937, Texas in 1943 and Florida in 1952 (Childs & Knorr, 1965). Indexing procedures for 15 virus disorders of citrus were detailed by a committee of experts (Childs _et al_. 1968). The initial work in Florida involved many apparently healthy citrus trees and after indexing them for a limited number of viruses, the accepted candidate trees constituted less than 1% of the old lines (Childs & Knorr, 1965). Virus diseases noted were tristeza, psorosis and cachexia (Bridges, 1960), exocortis (Childs _et al_, 1958) and bark scaling (Norman, 1965). The testing was considered by Childs & Knorr (1965) as extensive, slow and not wholly adequate. This situation, not anticipated when the bud certification programmes were launched, compelled the citrus virologists to look to eliminating viruses through budwood by other means.

Citrus viruses are not known to be seed transmitted with the possible exception of psorosis on carrizo citrange (Childs and Johnson, 1966). Besides, the phenomenon of nucellar embryony in citrus wherein citrus grows true to type from seed (Swingle, 1948) afforded a potential source of budwood free from non-insect and bud transmissible viruses. Encouraged by the success in this method (Knorr and Childs, 1968) which resulted in superior survival rate of nucellar lines (Childs and Knorr, 1965), work on similar lines is being initiated.

The use of nucellar embryony is believed to be the most reliable means of freeing citrus clones from viruses (Cameron et al, 1959, Weathers and Calavan, 1959). Considering the prospects of the nucellar lines, efforts were made to develop nucellar lines of mosambi by hybridisation at Poona as early as 1956. Budwood from 2 or 3 years old nucellar lines so developed was multiplied on 16 different rootstocks. As a check, budwood from old lines both apparently healthy and visibly diseased was also multiplied on the same rootstocks. The nucellar lines were highly vigorous, thorny and exhibited longer juivenile period than the old lines which were medium in size and bore fruits within 4 or 5 years. However, the nucellar lines produced stray fruits from 6th or 7th year onwards and later on also, did not register high yields relative to their size. The fruits were also big in size, had thicker rind with less juice content and poor in quality. Further, they were infected by tristeza and greening virus and started declining from 7th year onwards. Judging from their performance in Maharashtra, nucellar lines do not seem to be as promising as in other countries like U.S.A., Brazil etc. This may be attributed to the possible prevalence of severe strains of tristeza and greening in our country along with the availability of highly efficient vectors for both the diseases in most part of the year. Nevertheless, nucellar lines have their own inherent merits of being free from vectorless viruses and highly vigorous. The long juvenility can be probably reduced by resorting to nucellar budwood from bearing mature seedling plantations. Taking advantage of the existence of seedling sweet orange (Sathgudi) gardens in a small pocket in the state, a begining is made in Andhra Pradesh to index the budwood from these sources. Results indicated that these sources are also infected by tristeza to some extent. One case of infectious variegation was detected where Lisbon lemon was used as an indicator. At this stage, it may be difficult to explain this factor except to state that considerable caution has to be exercised when nucellar budwood is collected.

Indexing of prospective old line parent trees in 1970-71 mostly budded on jambari indicated widespread presence of tristeza, and to a lesser extent greening. An unforeseen result in indexing was the frequent occurrence of infectious variegation when Lisbon lemon was used as an indicator (Reddy <u>et al</u>, 1971). This established that great caution has to be exercised when old lines are used as parent trees simply because they are horticulturally desirable and do not exhibit any visible virus symptoms in the field except mottling.

Work on development of nucellar lines of about 170 sweet oranges and allied varieties is initiated at Tirupati since 1970. These lines are under constant watch for incidence of any other disorder and grown under insect free conditions. Method adopted to detect them as nucellar lines is the conventional visual method by which only seedlings of uniform vigour are retained

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discarding the poor and over vigorous seedlings. Cultivation of nucellar lines as a source of virus free budwood is tedious and time consuming. In general, seedling progenies of sweet orange take quite a long time to come to bearing. Thereafter, it is necessary that we critically examine fruit characters and yield potential for a minimum period of five years. The long delay in case of the sweet oranges can only be circumvented by resorting to collection of budwood from mature, bearing sweet orange seedling trees (Childs & Knorr, 1965) which are luckily available in a few gardens in the state. True value of budwood from the newly developed nucellar lines cannot be realised immediately.

DISCUSSION

The need for greater production in citrus based on the concept of longer productive life hardly needs any emphasis. This can be obviously achieved through use of virus free plant materials. Indexing of apparently healthy as well as visibly diseased sweet orange buddings in the state indicated the widespread presence of bud transmissible virus diseases, thereby compelling a search for virus free budwood from other sources. The results of a similar indexing in the early years of bud certification programme in Florida showed that less than 1% oldline trees indexed, were virus free (Childs and Knorr, 1965). Use of nucellar budwood was considered more advantageous under conditions existing in Florida, California, Brazil, Argentina, Morocco and various other countries.

However, under Indian conditions wherein severe strains of tristeza and greening occur along with their effecient vectors in adequate numbers, the nucellar lines are as much exposed to these viruses as old lines as experienced in Maharashtra since 1959. They are also not found to be more tolerant to these vector transmitted viruses than old lines. One point in favour of nucellar budwood is its certain freedom from Known and unknown viruses which are bud transmissible. If only the long juvenility can be reduced, nucellar budwood still appears to be promising. This setback can be overcome by resorting to use of budwood from mature, bearing seedling trees wherever they are available. The existence of such mature, bearing sweet orange (Sathgudi) plantations in Andhra Pradesh is being exploited as a future source of budwood.

The rare instances of seed transmission of viruses (Childs & Johnson, 1966) have to be recognised against the possible contamination and distribution into the citrus orchards. In the preliminary indexing of mature nucellar sweet orange trees at Tirupati, one sample indicated infectious variegation when indexed on Lisbon lemon. This is a good warning against indiscriminate use of budwood even from the nucellar seedlings without a routine programme of indexing of sources of budwood.

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The present knowledge of incidence and spread of citrus viruses points out that nucellar lines provide the most certain source of virus free budwood. Such budwood can be expected to be free from both known and unknown viruses. Routine indexing of the mature nucellar seedling trees may take the same time as the old lines. At the same time, indexing of old budding trees/of acceptable standards and all the trouble and money invested may not commensurate with the results. On the contrary, nucellar lines may no doubt contain some of the vector borne viruses and practically none of the vectorless viruses. Hence the advantage of nucellar lines, the setback of longer juvenility of nucellar lines can be overcome by using budwood from mature, bearing seedling trees. As such, best start of bud certification programmes in new areas appears to be with budwood of mature nucellar plants duly indexed and build up of nucellar lines for future.

/may ultimately result in extremely few candidate trees

SUMMARY

Based on the experiences in other countries like U.S.A., nucellar lines of sweet orange as source of budwood in the early trials in Maharashtra, though vigorous did not give the expected results. This is attributed to the long juvenility and prevalence of severe strains of tristeza and greening along with their most efficient vectors. Nucellar budwood from mature seedling sweet orange trees in Andhra Pradesh showed promise in the indexing trials. Development of nucellar lines of about 170 sweet orange and allied varieties in Andhra Pradesh is in progress.

Despite the setbacks in the early work in Maharashtra, nucellar lines seem to be a promising source as they are free from vectorless viruses and are vigorous, provided the long juvenility is minimized by resorting to mature, seedling trees, wherever they are available. It is considered, that the nucellar lines also should be indexed before they are utilized for propagation, to eliminate any contamination. As such, the best start of bud certification programmes in new areas appears to be with budwood of mature seedling trees duly indexed.

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ABSTRACT

Based on the experiences in other countries like U.S.A., nucellar lines of sweet orange as source of budwood in the early trials in Maharashtra, though vigorous did not give the expected results. This is attributed to the long juvenility and prevalence of severe strains of tristeza and greening along with their most efficient vectors. Nucellar budwood from mature seedling sweet orange trees in Andhra Pradesh showed promise in the indexing trials. Development of nucellar lines of about 170 sweet orange and allied varieties in Andhra Pradesh is in progress.

Despite the setbacks in the early work in Maharashtra, nucellar lines seem to be a promising source as they are free from vectorless viruses and are vigorous, providing the long juvenility is minimized by resorting to mature, seedling trees, wherever they are available. It is considered, that the nucellar lines also should be indexed before they are utilized for propagation, to eliminate any contamination. As such, the best start of bud certification programmes in new areas appears to be with budwood of mature seedling trees duly indexed.

ALL INDIA SEMINAR ON CITRICULTURE
NAGPUR - 1972

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BUDWOOD CERTIFICATION FOR SWEET ORANGE: ITS ROLE IN THE FUTURE OF CITRUS INDUSTRY

By

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The citrus industry all over the country has been affected with a serious malady termed die-back which has been taking a heavy toll of established plantations. Fraser (1966) who surveyed the citrus areas in various states of India for three months to assess the possible causes and identify causal viruses and other infections at the request of the Government of India concluded that the malady is due to greening virus. This conclusion was followed by additional information (Fraser and Daljit Singh, 1968, 1969). Gupta et al.(1969) assayed large number of bark samples from declining sweet orange trees in Punjab, Himachal Pradesh and Uttar Pradesh by the Schwarz Chromatographic test (Schwarz, 1968). Among the 626 trees so assayed, 433 were positive for the greening marker substance viz. gentisoyl glucose indicating the incidence of greening in the area to be 69 per cent. This figure is likely to be still higher if further extensive work is carried out to cover all the sweet orange growing areas. Knorr (1969) opined that despite the wide distribution of greening in Punjab it will be misleading to suggest that this disease is solely responsible for the decline of sweet orange in Punjab. He suggested that other factors like high soil pH, salinity, inadequate drainage and intercropping also may be contributory factors requiring attention. He suggested that these factors should be eliminated one by one to pinpoint the root cause of the malady.

Electron microscopic studies by Laflechc and Bove (1970) indicated the presence of mycoplasma-type bodies in greening-infected sweet orange plants. Ghosh et al.(1971) isolated a mycoplasma-type organism from greening-infected plants. When the ultimate proof of the mycoplasmal etiology of the disease is presented by fulfilling Koch's postulates it may still be useful to use certified greening-free budwood for propagation. Protection against infection in field will be possible by further work on the control of mycoplasma by the use of tetracycline antibiotics. In the absence of conclusive proof of mycoplasmal etiology, greening is treated along with other virus diseases of citrus in this paper.

Among the 15 viruses affecting citrus, only 3 viz. tristeza, greening and exocortis have been shown to be present in in India by indexing. In addition, dyloporosis (Cachexia), psorosis and vein enation and woody gall are also suspected to be present. Since the sweet orange plantations in Punjab are on rough lemon rootstock which is tolerant to tristeza this virus is not likely to pose a threat to the sweet orange industry in this region. The performance of tristeza-positive sweet orange trees ... during the past six years at the Regional Fruit Research Station, Abohar lends support to this view.

Exocortis virus does not have any insect vector and is transmitted by the use of infected budwood and contaminated budding tools and pruning tools. Hence control of this disease can be easily achieved by the use of virus-free budwood for propagation and sterilising the budding tools with chemicals like trisodium phosphate. Rough lemon rootstock is tolerant to this virus also.

The importance and scope of indexing for citrus viruses have been already reviewed (Jeyarajan, 1970). The budwood certification programme envisages selection of candidate trees with desirable horticultural attributes and freedom from symptoms of virus-diseases. The trees are then indexed on a set of indicator plants for important citrus viruses to ascertain their freedom from viruses. Trees showing negative results on indicator plants are then registered as sources of virus-free budwood and are subjected to periodic short term indexing.

The results of indexing work have shown that greening is largely responsible for sweet orange decline in Punjab. Rehabilitation of the citrus industry on a sound footing can be effected by a two pronged drive consisting of an intensive eradication programme against the psyllid vector Diaphorina citri and use of greening-free budwood for propagation. With the available systemic insecticides and methods to cover large areas in short time, it will not be difficult to eradicate the citrus psylla. The successful eradication of bunchy top of banana in Australia despite the fact that it is transmitted by an aphid vector may be cited as an example in this connection. Unlike tristeza and exocortis viruses which are severe only on certain stionic combinations, greening is predominently a disease of the sweet orange regardless of the rootstock and all the major commercial varieties are equally susceptible. Hence search for a resistant rootstock will not solve the problem. The practice of using budwood from any tree without verifying the presence/absence of viruses has helped in the wide dissemination of greening in the first instance followed by vector transmission to other healthy plants. Therefore the bud certification programme is of paramount importance towards re-establishment of a productive citrus industry in the country.

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ABSTRACT

The propagation of sweet orange plants without verifying the vital status of the sources of budwood has resulted in the wide dissemination of diseases like greening. Use of certified virus-free budwood for propagation is necessary to assure clean planting material. The importance of indexing for citrus viruses to achieve this objective is reviewed in this paper. The role of viruses in the die-back problem of sweet orange is evaluated. The prevalence of greening disease over wide areas in Punjab, Himachal Pradesh and Uttar Pradesh has been confirmed by chromatographic testing for the presence of greening-marker substance in declining sweet orange trees.

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Item No. ~~13~~ (1)

ALL INDIA SEMINAR ON CITRICULTURE

NAGPUR - 1972

A PLEA FOR THE ESTABLISHMENT OF INTEGRATED CITRUS ADVISORY CELLS

By

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Until rapid screening methods like the serological detection of the Crinky leaf type virus (CLTV) (Garnsey and Purcifull, 1970), are developed for the more important viruses associated with citrus decline and more complete information is available on the life history, habits and flight range of insect vectors, little progress can be made with either the bud certification schemes or the development of resistant strains by breeding or mutation. Further, viruses are only part of the problem and there are several other facets of Citrus decline on which the last word has not yet been said. It is becoming more and more apparent that no radical cure is within sight and we must learn to live with it. While research workers must continue their attempts to narrow down the gaps in our knowledge, it needs little emphasis that some practical measures must be initiated to contain the problem.

In Andhra Pradesh, citrus is shifting to new areas abandoning old sites with chronic decline problem. It is an urgent necessity to see that atleast the new sites are free from the malady. Uncongenial soil are, as shown by several workers (Chapman et al., 1946; Kanwar and Randhawa, 1960), a primary predisposing factor. It would, therefore, be wise to organise soil testing services in the new areas. Indiscriminate plantings would only extend grief to the new areas.

It has been the opinion of many research workers and experienced growers that good management wins half the battle against decline. Good management consists of proper irrigation, manuring and tree sanitation and practices helping better fruitset and retention. Of these, the first three aspects are more directly related to decline. It is, therefore, necessary to provide sound advice to growers in the management of orchards at top efficiency, so that even infected plants may, ignoring the virus, fulfil their production potentialities.

If Advisory services are to be organised, it would be necessary to define the nature of assistance they are expected to render. There are already a number of Soil Testing Laboratories all over the country. But they are not oriented particularly to help Citrus Industry. Besides the laboratory tests they carry out, it would be necessary to render field advice after inspection of site on such matters as national drainage, depth of water table and uniformity of soil. Soil physical characteristics like texture, structure porespace, moisture equivalent etc., are helpful not only in deciding the suitability of the site but also in irrigation management and indirectly in fighting decline. Subsoil structure also needs attention as a hard pan in the subsoil zone has been reported to be one of the major causes of decline (Naidu and Rao, 1958). Root limiting zones close to the surface such as stiff clay, high water table and hard pan can be hazardous unless careful irrigation regimes are planned.

The chemical characteristics of the soil appear to have a more direct bearing on decline. Calcareous layers in the subsoils have been long reported to affect tree health (Hillgard, 1906). Though Guest and Chapman (1944) found that high pH *per se* was not harmful to citrus, high pH has been generally associated with decline apparently because of impaired availability of micronutrients and the ill effects of high exchangeable sodium (Singh and Randhawa, 1969). Bernstein (1964) has set a tolerance limit of salinity for Citrus at 4 m mhos/cm in saturation extracts. But citrus has been known to suffer in soils with a conductivity of even 2.5 m mhos/cm which may be attributed to individual ions like sodium, boron, chloride and sulphate. It would, therefore, be necessary to have the soil analysed for individual ions including micronutrients. Analysis of irrigation waters should also be done before the orchard site is chosen and preferably at intervals after the establishment of the orchard.

Nematodes in the soil are an equally important cause of decline and preliminary as well as subsequent occasional analysis of soil for their species and population is necessary especially in view of the reports of beneficial effect of soil fumigants even in orchards with standing trees (Platt, 1968).

While some sort of soil testing service is available, we have not established any Leaf Analysis service. The ranges of leaf levels of all important elements and their association with cropping have been worked out (Embleton *et al.*, 1969) and similar standards have also been attempted in this country (Kanwar *et al.*, 1963: Aiyappa *et al.*, 1967). It is accepted that the best guidance for citrus fertilization must come from foliar assessment (Smith, 1966; Chapman, 1968). Leaf levels have also been correlated with quality of fruit (Chapman *et al.*, 1969(a). Toxicity of certain elements by themselves (Chapman *et al.*, 1969 (b) or as secondary effects due to excess of other elements, ion antagonisms and interactions may easily be detected

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by correlating soil and leaf analysis with visual symptoms, if any. An annual leaf analysis and periodical soil analysis should be considered together for advisory fertilizer schedules. The elements to be reported upon should not be limited to the macronutrients N, P, K, Ca, Mg and S alone but should also include the micronutrients B, Fe, Mn, Zn and Cu.

The soil and leaf analysis units may do a better job, if Analysis Report Blanks are prepared in order to ensure that all relevant characteristics are reported without missing any.

The establishment of Leaf Analysis units as an integral part of Citrus Advisory Cells along with the Soil Analysis units is the first step in the direction of crying a halt to the devastation of the Citrus Industry. Citrus is more or less localised in a few locations in several States and there may not be more than six such zones in each State which need attention. It would be feasible to establish an integrated Citrus Advisory Cell in each of them to analyse soils and leaves, and render advise and help on fertilisation, management and plant protection.

For a comprehensive approach, the following additional steps would be ideal from a rational point of view. It is recognised that their implementation rests on sociological and administrative considerations. Nevertheless, it is felt desirable to invite attention to them.

1. Registration of nurseries: This is with the sole object of identifying the source of supply of plant material and no license fee need be charged. But nurseries should be insisted upon to maintain plant distribution registers showing the names and addresses of the purchasers, number and varieties supplied, rootstock on which budded. It is preferable that the Citrus nursery trade is taken over by the State for the present. It will not be unmanageable as even with 2,000 hectares of new and renewal plantings a year, the requirements of plants can be met from about 20-25 ha of nursery area.

2. Registration of new Citrus orchards: This is with a view to render timely advice on choice of site and plant material. Registration of even old orchards will be desirable as it makes it possible to reach every grower and render advice and help through the Citrus Advisory Cells.

3. Isolation of new orchards: Till flight range of insect vectors are known, we have no scientific basis to fix distances of spatial isolation. But a distance of two miles may be considered a reasonably good isolation distance between blocks of new and old orchards.

The registration and advisory work can be coordinated well by both of them being entrusted to a single authority. The credit and other subsidies, if any, may preferably be routed through the authority. These steps may keep the decline under check and save the Citrus Industry from extension which, otherwise, seems to be its inevitable destiny.

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ABSTRACT

In order to check the decline in old orchards and its spread to new ones, it is suggested that Citrus Advisory Cells may be organised in citrus zones, where, at one place, an integrated advice on all aspects of Citriculture such as site selection, soil analysis, leaf analysis, plant protection etc., will be available to both prospective and current growers. The desirability of registration of nurseries and orchards and isolation of new orchards from old is also mentioned.

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NECESSITY OF MAINTAINING PROPER CITRUS NURSERY TAKING INTO CONSIDERATION THE PROBLEM OF CITRUS DECLINE

By

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Although, the present concept of citrus die-back in India has been generally accepted as a complex malady in which all factors of plant growth and production are involved, mal-practices in citrus nursery can be considered as one of the important factors involved for the malady in orchards in the latter stage.

It is seen that in major part of the country citrus nurseries are being maintained by ignorant, ambitious private nurserymen; and the buyer is equally ignorant of the genuine planting material and sources of reliable and dependable nursery plants (Naik, 1949, Aiyappa and Nanjappa, 1957, Knorr 1969). Therefore it is quite essential to curb such mal-practices and to educate the nurserymen on the scientific method of raising citrus plants in the nurseries. A good success in citrus growing depends much on the quality of plant material chosen for planting and hence a 'know-how' on raising a good nursery to provide dependable and genuine planting material is of prime importance. Efficiency in nursery management and planning are essential, and this is acquired both by education and experience. Without a basic knowledge of the methods of nursery raising and a desire to constantly expand that knowledge by keeping in contact with the results of research, citrus orchading may be risky. Recently the role of certain viruses such as tristeza, greening etc., being involved in the problem of citrus decline has been brought to lime-light. Taking into consideration this aspect the importance of using genuine planting material becomes very essential. In the following some suggestions have been brought out for future citrus nursery raising which may help in productive orchading.

Selection of nursery site.

It has been observed that at many places the nursery sites are located in areas of poorly drained, heavy soils. Such soil conditions retard root development and also favour infection to root-rotting fungii like Phytophthora sp; Fusarium sp; Phythium sp; Rhizoctonia sp; etc. causing damping off in seed beds and collar rot in nurseries. The plants which have recovered and are looking apparently healthy may be the vehicle for carrying pathogenic fungii to the orchard (Knorr 1969). These problems can be minimised to a great extent by selecting sites on light, sandy and well drained soils near a perennial water source. The soil fertility should be fairly high. Such soil conditions encourage luxuriant root development and in obtaining plants free from infections of root rot diseases (Srivastava et al 1969, Knorr 1969). The site once used should be allowed for fallowing before it is again used, to avoid soil sickness. It is more safer to rotate the sites or to change the old site to a new site after raising single crop of nursery. The soils of fallowed, old nursery sites should be fumigated against accumulating fungi, soil insects and nematodes.

Preparation of seed bed

The seed beds may be prepared at the ground by raising the beds 8-10" from the ground surface. Usually a 3-4" thick layer of well seived river sand is spread evenly over the bed of 5-6" soil already raised. The seed bed may be 3' wide and of any convenient length. In high rainfall tracts, the beds may be prepared on specially erected structures using bamboo and wooden poles ensuring perfect drainage and to check the incidence of ants and termites. Before sowing the seeds, at least 10-15 days earlier, the beds may be treated with 1% Bordeaux mixture or other fungicides like Captan, Thiram or Vapam. Gammaxine dusting may be given periodically around the beds to prevent ants.

Collection of seeds and budwoods

Seeds for rootstocks: Nurserymen often commit mistakes in the procurement of seeds. Seeds of all types and varieties are collected indiscriminately, sometimes even from juice factories (Knorr 1969) for raising stock seedlings and sold under popular rootstock labels. Seeds of Sour orange, Acid lime, Lemons, Pummelo, Grapefruit etc. should not be used since they have been found to be unsuitable as rootstocks mainly due to the susceptibility of

stock/scion combinations to tristeza virus when budded on these stocks. Certain important root-stocks which have good scope for popularisation are Rangpur lime, Poncirus trifoliata, Cleopatra mandarin, Kodakithuli, Rough lemon strains in certain regions and Karna Khatta. It is quite essential that fruits from true to type or botanically pure varieties of recommended stocks should only be procured for seed purposes. As far as possible the mother trees must be apparantly healthy, green and vigorous with good bearing capacity.

Seedlings that emerge in the seed bed may contain sexual or hybrid or off type seedlings and such variants should be rougues off or eliminated carefully before taking up budding in the nursery. Elimination process must start in the seed bed and continue upto the last budding stage. About 10-30% of the seedlings may have to be eliminated depending upon the variety (Srivastava et al 1969). This process ensures greatly towards getting true-to-type nucellar seedlings in the beds and such nucellars posses the genetic make up that will tolerate viruses like Tristeza, Xyloporosis and Exocortis while the sexuals often succumb when infected bud-wood is used (Knorr 1969).

Seeds and Budwoods from Scion mother trees

High yielding, regular bearing, disease free, healthy, green and vigorous trees, aged between 20-30 years should only be selected as mother trees for seed purposes in case seedling plantations envisaged to be planted. As far as possible the past performance of such trees must be known. After extraction of seeds only bold, well filled, healthy seeds should be selected for sowing. According to Knorr (1969) pedigree is actually of greater importance in the purchase of citrus seed than in the buying of horses. Trees to be selected for budwoods should have high productive capacity, producing high quality fruits, true to type for the variety, free of abnormal variations in vigorous condition, free from pests and diseases, free from virus diseases and the bark of the trees free from any active bark symptoms. After having selected the trees, green healthy branches bearing good sized, uniform coloured fruits should be further selected and branch variation due to bud-mutation should be avoided.

Before sowing the seeds may be treated with Captan or Cerasan or with Thiram to kill seed-borne infections. Hot water treatment of seeds at 115-124°F for 10 minutes ensure the kill of Phyto-phthora organisms. (Klotz et al 1960). It is

desirable to give a spacing of ½-1" between seeds while sowing in seed beds.

In the case of procurement of citrus budwoods, one has to be more cautious and also more concious of the presence of viruses in the selected mother trees. Such trees should be indexed under budwood certification programme which is under operation at different centres in India namely: Poona, Tirupathi, Abohar, New Delhi, Kalimpong, Kahikuchi, Gonicoppal etc., sponsored by Indian Council of Agricultural Research and only such candidate trees free from viruses should be selected for budwood purposes. It is sufficient that the trees selected are free from viruses like Tristeza, Exocortis, Greening, Stubborn, Psorosis and Xyloporosis. Since the certification programme involves lot of expenditure and technical skill, private nurserymen will have to depend on Government or Departmental agencies for the virus free budwood materials. Until this programme of indexing gets into operation there exists the risk.

Transplanting in nursery beds

Nursery beds should be prepared in good fertile, sandy-loam soils. About 25-30 cart loads of well decomposed farmyard manure per acre may be applied at the time of preparation of nursery beds. These beds may be raised 8-10" from the ground to ensure good drainage. The nursery plants must be copiously watered. Organic and in-organic fertilizers may be used periodically to encourage healthy growth of the plants. While transplanting, the seedling should be spaced at least 12" apart in the beds to provide enough area for root development both for seedlings and for stock plants.

Budding operation

Patch or modified forkhert method may be employed. While budding, height of budding level should be as high as 10" from ground level to avoid infection of foot rot (Phytophthora sp.) in orchard plantings. Plants with low bud unions are easily susceptible to foot rot or stump rot diseases (Knorr 1969).

Sanitary condition.
Control of insect pests and diseases in the nursery, etc.

In addition to the above mentioned precautions it is highly desirable to maintain the nursery stock strictly under insect pests and disease free condi-

tion by adopting preventive and control measures at regular intervals. Nursery beds must be weed free at all times to avoid competition for water, manures and space which otherwise may lead to stunted and sickly growth of the plants. Insects like Aphids, Psylla, are vectors of viruses like Tristeza and Greening and hence efficient control of these insects at nursery is important. Other pests like leaf miner and orange dog also hinder the growth of plants and are to be controlled timely. Among diseases, collor rot, powdery mildew, canker and scab are important. These should be controlled by timely sprayings with suitable fungicides.

In this discussion, only certain important aspects of nursery maintenance have been dealt. If citrus decline is to be controlled in our country it is essential that only genuine planting material is distributed and planted in the orchards. Whether it is seedling plantation or budded plantation which is envisaged in an area this aspect should be considered seriously. It is encouraging to note, that bud-wood certification programme has been envisaged in the country. Under this programme genuine planting material will be supplied in due course of time. The programme in short contains:- 1. To survey and index the commercial citrus varieties of the region for freedom from viruses and to select such virus free healthy, good performing trees as future mother trees for seed and bud-wood purposes. 2. To inspect, certify and register donor trees for bud-wood sources in co-operation with progressive nurserymen. 3. To study the reaction of various stionic combination to different viruses. 4. To study on the ecology of the vectors, citrus psylla and aphid with a view to evolve suitable control measures thereby checking the insect borne viruses. 5. Evolving and standardising techniques for quick detection of viruses in bud-wood source. We feel certain if this programme materialises successfully the citrus industry in the country will improve and growers will develop confidence in citriculture. However until this programme establishes it is essential that the supplies made to the growers are the best possible materials. Therefore, it is suggested that there should be long range and short range programmes.

<u>Suggestions for future line of work</u>

A. <u>Long range programme</u>.

1. Private citrus nursery enterprise may be (as far as possible) discouraged and more emphasis must be given to government agency nurseries.

2. Nursery inspection or bud-wood certification scheme must be strictly introduced in all the citrus growing areas.

3. Bud-wood bank orchards should be opened to maintain pedigree mother trees free from viruses for future multiplication.

4. Nucellar lines free of viruses may be evolved by using trifoliate pollen. Such nucellar seedling trees should be indexed for certain viruses like, Greening, Psorosis, Xyloporosis/Cachexia, etc., and then, they should be registered for future bud-wood selection.

5. More rootstock trials may be taken up using Rangpur lime, Trifoliates, Cleopatra mandarins, Rough lemon etc., under different soil and climatic conditions in order to recommend particular strain/strains for a particular zone.

B. <u>Short Range programme</u>.

Mother trees aged 20 years and above, bearing consistently per tree per year may be selected by indexing for viruses like Tristeza and Greening for the moment and they can be used for virus free bud-wood sources in future.

2. In case such virus free mother trees are not available for immediate nursery purpose, the bud-woods should be collected as far as possible from the known healthy, green, high performing, regular cropping, free from visual symptoms and twig drying, and from trees aged about 20-25 years.

3. The Government nurseries should make every effort to maintain nursery stock free of diseased and symptomic plants by periodic roughing for distribution to the growers. The nurseries must be maintained at high sanitary condition by adopting regular spraying schedule against insects particularly aphids, psylla and leaf miners.

4. As far as possible the nursery stock should be uniform in height and vigour, true to type by rouging out weak as well as very vigorous seedlings in the nursery beds to an extent of 20-30%. This process may ensure nucellars in the nursery.

It is suggested that more rootstock trials and other trials, taking into consideration the virus involvement, are carried out in the country. Based on the results of such trials our nursery activities should be reoriented, and perfected. There should be a link with the achievements on various aspects of citriculture and nursery plant maintenance for supplies.

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Item No. 12

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The pests of Citrus

Dr. B.L. Bhamburkar

The citrus fruit is grown in tropical and subtropical regions throughout the world. From the point of view of the size of the industry and deliciousness of the fruit none can dispute the importance of citrus fruits. In acreage, the citrus fruits probably rank third among the subtropical fruits of the world, with more than 2,000,000 acres. In India the area under the citrus fruit cultivation is estimated to be 2,54,641 acres.

Citrus species viz. *Citrus aurantium* (bitter or sour orange), *C. Sinensis* (tight skin sweet orange or malta) *C. reticulata* (loose skinned mandarin orange), *C. indica* (wild orange) *C. Maxima* (Pumelo), *C. medica* (citron), *C. limon* (Lemon), *C. aurantifolia* (sour lime), *C. limetta* (Sweet limes), *C. megaloxycarpa* (Sour pumelo), *C. paradisi*, (grapefruit), *C. jhambiri* (jhambhiri) *C. karna* (Karna) etc. are the various citrus species grown in the various states all over India. These species are almost attacked by the pests which are common to most of them. Hence they are considered as a group.

More than 120 species of insect pests have been reported to attack citrus plants. Apart from them a number of noninsect pests like rats, various species of mites, birds, monkeys and nematodes are found to damage citrus cultivation. All these pests take a very heavy toll every year resulting in a great national loss. An attempt is being made here to deal the important insect and non-insect pests of citrus damaging leaves, stem, bark, inflorescence, fruits and roots of citrus separately.

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(A) Pests attacking leaves of citrus

The insect pests attacking leaves of citrus include the following:

1.	The lemon butterfly	Papilio, demoleus, Linn, Lepidoptera
2.	Other papilio species	P. polytes
3.		P. memnon
4.		P. helenus daksha
5.		P. polymnestor
6.		P. machaon, asiatica
7.	Leaf miner	Phyllocnistis citrella St.
8.	Leaf folding caterpillar	Tonica zizyphi s.
9.	Citrus psylla	Diaphorina citri K.
10.	Citrus aphid	(I) Toxoptera aurantii(Bd.F) (II) Aphis taveresi (Del Guer)
11.	Thrips	(I) Thrips florum Sch. (II) T. Subnudula (Karny) (III) Heliothrips haemorrhoidilis(Bouche)
12.	Citrus white flies	(i) Dialeurodes citri (Rilay and Howard)
	(Woglum black fly)	(ii) Aleurocanthus woglumi Ashby.
	(husain black fly)	(Iii) A. husaini(Corbett)
	citrus black fly	(IV) Aleurocanthus spiniferus Quein
13.	Citrus scales (Hard scales)	Aspidiotus ficus A M A aurantil Parlatoria Zizyphus L
	Soft Scales	Lacanium viride G L Wesperidum L Saicssetia hemispherica T

Cottony cushion scale *Icerya purchasi* M

14. Mealy bug *Pseudococcus corymbatus* G

Phenacoccus iceryoides G

Thus more than twentyfive insect species belonging to different orders are found to feed on the citrus leaves and damage them, either by sucking the juice, mining the leaf lamina or by consuming the leaf blade as such. In case of some of the species the damaged leaves drop down and the plants get defoliated. The butterflies of the papilio species oviposit singly on the tender leaves of citrus plants. The caterpillars feed on the leaves voraciously from the margins towards the midrib and destroy them. Sometimes very heavy breeding of these pests takes place on citrus as well as on the alternate hosts namely Bel (Aegle mormelos), meetha neem (Murrayia sp) Bheria (Chlorxylon Swictenies DC) and the butterflies appear in swarms. The plants in nurseries as well as orchards get completely defoliated, (this had occurred in vidarbha region in 1968) on account of the feeding of innumerable caterpillars at a time.

Shaking of plants and hand picking of larvae has been found to be suitable when the incidence is low. In case of heavy infestation only of the following treatments can be used successfully.

1. Spraying with 0.25% lead arsenate with gur or molasses.
2. 0.1 to 0.16% BHC (2) 0.02@ endrin 20 E.C.
3. 0.16 to 0.25% DDT (5) 0.1% pyrethrum emulsion.

The caterpillars of some miner pests like the castor slug *Parasa lepida* Gram. and *Euproctis fraterna* have also been found to feed on leaves. They can be easily controlled by BHC spray (50% BHC).

The leaf miner is a very serious pest in the nurseries. The tender leaves of grown up plants at the time of new flush are generally attacked by this pest. In case of heavy infestation

Contd.4

the old leaves are also damaged. The larvae mine the leaves in a zig zag manner. Generally two larvae are observed on one leaf (one on the either side of the midrib). The mine of the larva is not found to cross the midrib due to the extensive mining by the pest, the leaf suffers badly, gets deformed and irregularly curled up in shape, unhealthy in look and defective in its function and finally it dries and falls off. The plant suffering from leaf miner becomes prone to diseases like citrus canker.

The adult is a tiny silvery shining moth with a wing expanse of 8 to 10 mm. Females lay flat eggs singly on the undeside of tender leaves. They hatch in about two days. The larva is never exposed. From the egg it directly enters the leaf tissue and srarts mining. After feeding for about five days it reaches the margin of leaf and pupates there in a fold of the leaf. Pupal period lasts for five days. Thus one generation takes 12 to 15 days for completion.

Spraying with 0.06 per cent nicotine sulphate with 1.0 per cent fish oil rosin soap or 0.16 to 0.25% DDT, or 0.1 to 0.2% BHC or 0.02% endrin, 0.025% parathion or 0.15% thiodan spray give a satisfactory control. Before the appearance of the new flush the affected leaves should be clipped off and destroyed. This should be followed by immediate spraying. The aphids, thrips and citrus psylla generally attack the newly formed tender shoots and suck the juice from leaves, branches and floral parts. In case of heavy infestation of aphids andpsyllids the new shoots are completly covered by the nymphs. Many of the leaves drop off in a very early stage of growth due to excessive drain of juice from the branches. Heavily infested shoots even die due to loss of sap. As there is a regular occurence of these insects, spraying should be started simultaneously with the appearance of the new shoots. Two more sprays should be given at an interval of ten days. A combined spray of an insecticide, fungicide and an acaricide has been found to be very effective. Spraying with thiodan + Morocide or endrin + copper fungicide+sulphur, has given good results at Nagpur. In place of endrin DDT, Diazinon, parathion or, BHC, can also be used effectively. These sprays also help in controlling the scale insects, mealy bugs and white flies.

Siddiqui (1952) recommended lime-sulphur sprays against eggs of white flies, lime-sulphur and 0.25 percent DDT/emulsion against nymphs and 3 percent Kerosene Oil emulsion against adults While Gupta and Haq (1958) reported lime-sulphur (1:20), DDT emulsion (0,5 per cent) and DDT+ Sulphur (both 0.5 percent) to be effective against eggs, larva and pupae respectively and diazinon, malathion, parathion dieldrin, metasystox and ekatin to be ineffective.

Apart from the insects, mites also suck the juice from the leaves of citrus plants and defoliate them. Mites being small in size often go unnoticed. The following species of mites have been reported on citrus from various places in India.

1. Tetranychus sexmaculatus	Assam.
2. T telarius	-do-
3. T. hindustanicus	Andhra and Kerala
4. Paratetranychus citri	South India
5. Phyllocoptes olevorius Ash	Andhra Pradesh.
6. Eutetranychus orientalis Klein	Nagpur.

More than three species of mites have been found to attack leaves and fruits in Nagpur. They are yet to be properly identified. Mites mostly remain on the backside of the leaves and suck the juice. The leaves affected by mites turn pale green in the early stage of attack, yellow later on and ultimately drop down, thus resulting in partial or complete defoliation depending on the intensity of attack. On the fruits various types of symptoms are produced by mites of different species. In some cases white ringlike spots are seen all over the rind. The rind becomes pale green or pale yellow in colour and the fruits drop down even with a small jerk. In other cases the rind develops cracks which may be superficial or even deep. In the central depression on the opposite side of the stalk the red mites cluster together and feed voraciously. As a result of this the rind at that spot gets torn off and the inner contents become visible. Due to such openings the fruits become susceptible to the attack of various other organisms like bacteria and fungi and drop down if attacked by them. In the third type the mites cluster at certain points

on the rind. Dome shaped eruptios apprar at such places and gradually spread in a horizontal band around the fruit. Consequently the rind of the fruit appears patchy and rough. Mites can be controlled by dusting sulphur powder, spraying 0.5% wettable sulphur, lime sulphur wash 0.025% parathion or morocide (40E.C.) 0.08%.

Pests attacking stem and bark

Among the pests that attack the stem and bark of citrus can be included.

1. Indarbela quadrinotata Wik(shoot and bark borer)
2. Stromatium barbatum (Fabor) (trunk borer) and
3. Rats of various species.

Ayyar (1940) has reported Arbela tetraonis, M. as a Shoot and bark borer from south India in addition to I quadrinotata. Similarly he has reported Chloridolum alcameno, Thom and Chelidonium cinctum, Guer, the longicorn-beetles damaging stem of citrus.

The moths of bark and shoot borers lay eggs in August and September in the cracks of bark and the caterpllars on hatching first feed on the bark and later on as their mandibles become hard bore into the stem at the point of branching. After entering the stem the larvae lead a concealed life and complete the life cycle in one year. The larva prepares a gallery of silken thread foecal matter and powdered bark on the stem leading from the opening of the burrow and feeds on the bark underneath this gallery during night. Only on dark cloudy days some larvae have been found to be active during daytime. Fullgrown larval measures 1½ to 2" in length. It pupates in the larval gallery. The adult is a stout built pale brown moth with vavy grey marks on the wings. The pest is observed to attack a number of orchard plants like guava pomegranate, jamun, and forest plants namely eucalyptus, Amla, bheria, meetha neem, Casuarina, rain tree, Peltophorum etc.

The Trunk borer is primarily a borer of dead wood but also bores into living branches. The branches attacked by these beetle borers generally die if not controlled at the proper time.

For controlling the shoot and bark borers and trunk borers EDCT mixture has been found to give very good results. Five to ten ml. of the mixture should be injected in the tunnel of the borer by a dropper and the opening should be sealed by mud (mixed with some fibre) and made airtight. The efficiency of the treatment depends on making the burrow perfectly airtight. After sealing, the galleries on the bark should be removed and destroyed. Observations should be taken again after 3 to 4 days. Only those burrows where the new galleries are observed should be treated again with little higher dose. Kerosene, Petrol, carbon, disulphide, Mixture of creosote and chloroform (1:2) have also been suggested by some workers but EDCT has been found to be very effective (as the fumes are heavier than air) and easy to handle.

Rats: In Vidarbha rats have been found to cause damage to bark. During night they climb the trees and feed voraciously on the bark. Cultivators generally do not believe this unless they actually observe the rats feeding on the bark. This can be detected in the orchards (suffering from such damage) by focussing powerful torchlight on the trees. The branches heavily damaged by rats ultimately die. Rats can be easily controlled by baits prepared with zink phosphide (any type of grain or flour 30 parts; zink phosphide I part and a little edible oil or gur or common salt dissolved in water).

(C) Pests damaging inflorescence:-

The pests damaging inflorescence include:

(i) Gall midge *Dasyneura, citri*

(ii) Aphids

(iii) Thrips and

(iv) Citrus psylla.

The gall midges have recently been observed to cause heavy damage to citrus buds throughout the year. The damage is very heavy during the period from November to March. Small Pink coloured gall flies are found to be active in the orchards between 9 a.m. and 4 p.m. laying eggs on greenish buds, which are in a very early stage of development. Five to seven eggs are laid singly underneath the petals by pushing the fine threadlike ovipositor from the central point where all the petals meet. The eggs hatch within 2 to 3 days and the white maggots start feeding on the androecium and gynaecium. After 5 to 6 days the maggots turn pinkish. Ultimately they turn pink within 3 to 4 days. The damaged buds become very weak due to excessive drain of juice, never open into flowers and become deshaped and pale in colour. Consequently they drop down along with the pink. maggots. The petals being fleshy (thick) the maggots do not receive any injury due to the dropping of buds. They come out from the buds and enter the soil to a depth of half to one inch for pupation. They pupate inside white papery cocoons. As the earth particles get adheared around these it goes very difficult to detect the pupae in the soil. The pupal period ranges from five to seven days. Thus one generation requires 15 to 20 days for its completion.

The pest can be easily controlled by two to three sprayings with thiodan 35 E.C. at the rate of 15 Ml in 10 litres of water (for hand operated sprayers and 15 Ml. in 30 litres water for low valume power sprayer). The first spray should be given at the time of appearance of the buds of first flush on the trees. In addition to this the soil underneath the tree should be treated with 10% BHC dust at the rate of 10 Kg. per acre (10 gms per tree) twice at one interval of 15 days. First application should be done at the appearance of the first flash of buds on the plants. The sprayings should be done during evening hours (between 5 P.M. and 8 P.M.) to avoid disturbance to bees and other insect pollinators which visit the flowers from morning till evening during the flush period. This has been found to be very effective. The other pests attacking inflorescence namely psyllids thrips aphids have already been dealt along with the pests infeseting leaves. All

these can be easily controlled by thiodan spray. If the mites are also present on the leaves a combined spray of thiodan and morecide 40 E.C. gives satisfactory results. Morocide should be added at the rate of 10 Ml. in 10 liter of water

(D) Pests attacking fruits:

These include the various species of fruit sucking moths pentatomid bugs mites, monkeys and crows. The fruit sucking moths attacking citrus are very peculiar on account of two reasons. Firstly they constitute one of the very few examples of adult lepidoptera doing direct damage to the crop. Secondly none of the remaining three stages of these insects come in contact with citrus, at any time. The larvae feed on entirely different plants (like Tinosporasp, Coculus sp., Castor, Quisqualis indica, rose etc.) most of which grow wild and even quite far away from the fruit orchards. Thus, as the breeding of these pests takes place outside the orchards on plants of less economic importance they remain unnoticed till the moths start damaging the citrus fruits. This always results in a sudden heavy incidence and large scale damage to fruits. Following species are noticed to act as citrus fruit sucking moths:

	Larval hosts
1. Othreis fullonica linn	Tinospora cordifilia
2. O.materna	-do-
3. Achaea Janita	Castor, rose etc.
4. Calpo ophideroides	-
5. C. emerginata F.	-
6. Anua Coronata F	Quisqualis indica
7. Ophideres Ancilla, Cram	-
8. Achaea tirrhaca Cram.	
9. Lagoptera honesta Hubn.	

The moths are very stout and capable of flying long distances. They puncture the rind of the fruit with their stout probosces and suck the juice from half ripe or ripe fruits. The puncturers on the fruits and the juice Oozing out from them expose the fruits to various secondary enemies like

bacteria, fungi and other insects due to which the fruits develop a circular scar around the puncture start rotting and ultimately drop down. Thus the orchards suffer a great loss on account of the fruit sucking moths particularly during the months of August, september and October.

Destruction of the larva hosts, in the citrus growing area has been found to reduce the fruit drop. Baptista (1944) summarised the methods tried for controlling the moths which include capture of moths by hand or nets, light traps, baited traps, with or without poison, disposal of fallen decaying fruits and early harvesting. The baits are to be renewed weekly. For A. janata the slices of citrus fruits already damaged by moths are attractive and may be used at vantage points for the collection and destruction of slugish moths.(Ramachandrachari c. and padmonabhan V.1960).

Amongst other pests that damage citrus fruits are the pentatomid Buds Rhynchothoris humeralis (Thunberg and Vitellus orientalis Distt. caterpillars of Dichocrosis punctiferalis (Guenec) and Prays endocarpa Meyerick, fruitflies Dacus dorsalis Hendel and D hagenij De Meijere. All these pests do not cause a very serious damage to the fruits. Various methods have been described for their control but they are not so effective. The mites attacking citrus fruits have already been dealt along with the mites infesting leaves.

Monkeys and crows generally attack the fruits when they are ripe. Various methods for driving them away or shooting can be employed effectively.

(E) Nematodes associated with roots of citrus plants:-

Following species of nematodes have been reported to be associated with the roots of citrus plants.

(i) Meloidogyne sp.
(ii) Xiphipoma americana Cobb
(iii) X basiri Stekk

(iv) citri Loos
(v) Basiria graminophila Buter
(vi) Tylenchulus semipenetrans

Tinumala Rao (1956) reported that the nematode Meloidogyne sp. even if present in citrus gardens. does not make its presence felt by the citrus growers. But when the susceptible inter crops like tobacco and bhindi are grown the nemotodes assume virulent form and attack citrus roots later on when intercrop is removed. Considerable damage by Meloidogyne sp. has been reported by Perraju (1960) Prasad and Chawala (1967) have reported P.I semipenetrans as a semiendoparasitic species on the roots of citrus.

ABSTRACT

More than 120 species of insect pests attack citrus plants. Apart from them a number of non-insect pests like rats, Mites, birds, Monkeys and nematodes are also found to cause damage to citrus cultivation.

These pests have been grouped as pests attacking leaves, buds and flowers, fruits, bark, stem and roots. Among the leaf damaging pests aphids, citrus psylla, mites, leaf eating caterpillars (Papilio sp.), and leaf miners cause serious damage. The gall midge Dasyneura citri is a serious pest on floval buds. Due to its damage to floral organs the buds do not develop into flowers and drop down as galls. The psyllids, aphids and thrips attack the new shoots when they are in the early stage of their development and result in great loss by reducing the number of floral buds. Mites and fruit sucking moths of various species attack the fruits causing fruit drop. In case of heavy infestation they actually snatch away the share of the orchardist when he is planning for a bumper harvest. The bark eating caterpillars, rats, and stem borer inflict a heavy loss to citrus cultivation by killing the branches. Nematodes though very minute in size do not lack in taking their share when the conditions are favourable for their growth.

To save the citrus cultivation from all the above named enemies a regular plant protection schedule has to be followed by the orchardist throughout the year. The schedule of plant protection measures for citrus:

1. Two applications of Bordeaux pest to tree trunks upto 3' height	(1) In May (2) In November.
2. Spraying with a combination of a good contact and stomach poison, fungicide and acaricide.	(i) 3 sprays at fifteen days interval during July-August-Sept. (ii) -do- during Dec.Jan-Feb. depending on the appearance of new flush.
3. Treatment of tunnels of borers by EDCT mixture	one or two applications as per requirement during December.January-February.

4. Soil treatment with BHC 10%	Two applications at the rate of 10 gms.per tree at 15 days' interval during each flush. First application to be given immediately after the appearance of buds on shoots.

Destruction of alternate hosts of fruit sucking moths especially Tinospora cardifolia and organisation of rat control campaigns in the citrus growing areas at least twice in a year-once in each season-kharif (June) and Rabi (November)